2024 FRM®
Exam Prep

SchweserNotes™
Credit Risk Measurement and Management

PART II BOOK 2

KAPLAN SCHWESER

Book 2: Credit Risk Measurement and Management

SchweserNotes™ 2024

FRM Part II

SCHWESERNOTES™ 2024 FRM® PART II BOOK 2: CREDIT RISK MEASUREMENT AND MANAGEMENT

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STUDY SESSION 4

17. Fundamentals of Credit Risk

Sylvain Bouteille and Diane Coogan-Pushner, *The Handbook of Credit Risk Management: Originating, Assessing, and Managing Credit Exposures, 2nd Edition* (Hoboken, NJ: John Wiley & Sons, 2022). Chapter 1.

After completing this reading, you should be able to:

a. define credit risk and explain how it arises using examples.
b. explain the distinctions between insolvency, default, and bankruptcy.
c. identify and describe transactions that generate credit risk.
d. describe the entities that are exposed to credit risk and explain circumstances under which exposure occurs.
e. discuss the motivations for managing or taking on credit risk.

18. Governance

Sylvain Bouteille and Diane Coogan-Pushner, *The Handbook of Credit Risk Management: Originating, Assessing, and Managing Credit Exposures, 2nd Edition* (Hoboken, NJ: John Wiley & Sons, 2022). Chapter 2.

After completing this reading, you should be able to:

a. define risk management responsibilities in an organization and explain the three lines of defense framework for effective risk management and control.
b. explain the processes that lead to risk taking including credit origination, credit risk assessment, and credit approval processes.
c. discuss the following key principles underlying best practice for the governance system of credit risk: Guidelines, Skills, Limits, and Oversight.
d. describe the most common parameters of a credit-sensitive transaction.
e. describe the roles of the credit committee in an organization.

19. Credit Risk Management

Hennie van Greuning and Sonja Brajovic Bratanovic, *Analyzing Banking Risk, Fourth Edition* (World Bank Group, 2020). Chapter 7.

After completing this reading, you should be able to:

a. describe key elements of an effective lending or financing policy.
b. explain the importance and challenges of setting exposure and concentration limits.
c. describe the scope and allocation processes of a bank's credit facility and explain bank-specific policies and actions to reduce credit risk.
d. discuss factors that should be considered during the credit asset classification process.
e. describe and explain loan loss provisions and loan loss reserves.
f. identify and explain the components of expected loss and distinguish between expected loss and unexpected loss.
g. explain the requirements for estimating expected loss under IFRS 9.
h. describe a workout procedure for loss assets and compare the following two approaches used to manage loss assets: retaining loss assets and writing off loss assets.
i. explain the components of credit risk analysis.
j. explain the components of credit risk management capacity, and outline key questions that the board of directors of a bank should ask.

20. Capital Structure in Banks

Gerhard Schroeck, *Risk Management and Value Creation in Financial Institutions* (New York, NY: John Wiley & Sons, 2002). Chapter 5, pages 170–186.

After completing this reading, you should be able to:

a. evaluate a bank's economic capital relative to its level of credit risk.

b. identify and describe important factors used to calculate economic capital for credit risk: probability of default, exposure, and loss rate.
c. define and calculate expected loss (EL).
d. define and calculate unexpected loss (UL).
e. estimate the variance of default probability assuming a binomial distribution.
f. calculate UL for a credit asset portfolio and the UL contribution of each asset under various scenarios of portfolio composition, asset characteristics and size.
g. describe how economic capital is derived.
h. explain how the credit loss distribution is modeled.
i. describe challenges to quantifying credit risk.

21. Introduction to Credit Risk Modeling and Assessment

Michalis Doumpos, Christos Lemonakis, Dimitrios Niklis, and Constantin Zopounidis, *Analytical Techniques in the Assessment of Credit Risk: An Overview of Methodologies and Applications* (Springer, 2019). Chapter 1.

After completing this reading, you should be able to:

a. explain the capital adequacy, asset quality, management, earnings, and liquidity (CAMEL) system used for evaluating the financial condition of a bank.
b. describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon.
c. estimate capital adequacy ratio of a financial institution.
d. describe the judgmental approaches, empirical models, and financial models to predict default.
e. apply the Merton model to calculate default probability and the distance to default and describe the limitations of using the Merton model.
f. compare and contrast different approaches to credit risk modeling, such as those related to the Merton model, Credit Risk Plus (CreditRisk+), CreditMetrics, and the Moody's-KMV model.
g. apply risk-adjusted return on capital (RAROC) to measure the performance of a loan.

22. Credit Scoring and Rating

Michalis Doumpos, Christos Lemonakis, Dimitrios Niklis, and Constantin Zopounidis, *Analytical Techniques in the Assessment of Credit Risk: An Overview of Methodologies and Applications* (Springer, 2019). Chapter 2.

After completing this reading, you should be able to:

a. compare the credit scoring system to the credit rating system in assessing credit quality and describe the different types of each system.
b. distinguish between through-the-cycle and point-in-time credit rating systems.
c. describe the process for developing credit risk scoring and rating models.
d. describe rating agencies' assignment methodologies for issue and issuer ratings, and identify the main criticisms of the credit rating agencies' ratings.

23. Credit Scoring and Retail Credit Risk Management

Michel Crouhy, Dan Galai, and Robert Mark, *The Essentials of Risk Management, 2nd Edition* (New York, NY: McGraw-Hill, 2014). Chapter 9.

After completing this reading, you should be able to:

a. analyze the credit risks and other risks generated by retail banking.
b. explain the differences between retail credit risk and corporate credit risk.
c. discuss the "dark side" of retail credit risk and the measures that attempt to address the problem.
d. define and describe credit risk scoring model types, key variables, and applications.
e. discuss the key variables in a mortgage credit assessment and describe the use of cutoff scores, default rates, and loss rates in a credit scoring model.
f. discuss the measurement and monitoring of a scorecard performance including the use of cumulative accuracy profile (CAP) and the accuracy ratio (AR) techniques.
g. describe the customer relationship cycle and discuss the trade-off between creditworthiness and profitability.
h. discuss the benefits of risk-based pricing of financial services.

24. Country Risk: Determinants, Measures, and Implications

Aswath Damodaran, *Country Risk: Determinants, Measures, and Implications – The 2022*

***Edition* (2022)**

After completing this reading, you should be able to:

a. identify and explain the different sources of country risk.
b. evaluate the methods for measuring country risk and discuss the limitations of using those methods.
c. compare and contrast foreign currency defaults and local currency defaults.
d. explain the consequences of a country's default.
e. discuss measures of sovereign default risk and describe components of a sovereign rating.
f. describe the shortcomings of the sovereign rating systems of rating agencies.
g. compare the use of credit ratings, market-based credit default spreads, and CDS spreads in predicting default.

STUDY SESSION 5

25. Estimating Default Probabilities

John C. Hull, *Risk Management and Financial Institutions, Sixth Edition* (John Wiley & Sons, 2023). Chapter 17.

After completing this reading, you should be able to:

a. compare agencies' ratings to internal credit rating systems.
b. describe linear discriminant analysis (LDA), define the Altman's Z-score and its usage, and apply LDA to classify a sample of firms by credit quality.
c. describe the relationship between borrower rating and probability of default.
d. describe a rating migration matrix and calculate the probability of default, cumulative probability of default, and marginal probability of default.
e. define the hazard rate and use it to define probability functions for default time as well as to calculate conditional and unconditional default probabilities.
f. describe recovery rates and their dependencies on default rates.
g. define a credit default swap (CDS) and explain its mechanics including the obligations of both the default protection buyer and the default protection seller.
h. describe CDS spreads and explain how CDS spreads can be used to estimate hazard rates.
i. define and explain CDS-bond basis.
j. compare default probabilities calculated from historical data with those calculated from credit yield spreads.
k. describe the difference between real-world and risk-neutral default probabilities and determine which one to use in the analysis of credit risk.
l. using the Merton model, calculate the value of a firm's debt and equity, the volatility of firm value, and the volatility of firm equity.
m. using the Merton model, calculate distance to default and default probability.
n. assess the quality of the default probabilities produced by the Merton model, the Moody's KMV model, and the Kamakura model.

26. Credit Value at Risk

John C. Hull, *Risk Management and Financial Institutions, Sixth Edition* (John Wiley & Sons, 2023). Chapter 19.

After completing this reading, you should be able to:

a. compare market risk value at risk (VaR) with credit VaR in terms of definition, time horizon, and tools for measuring them.
b. define and calculate credit VaR.
c. describe the use of rating transition matrices for calculating credit VaR.
d. describe the application of the Vasicek model to estimate capital requirements under the Basel II internal-ratings-based (IRB) approach.
e. interpret the Vasicek's model, Credit Risk Plus (CreditRisk+) model, and the CreditMetrics ways of estimating the probability distribution of losses arising from defaults as well as modeling the default correlation.
f. define credit spread risk and assess its impact on calculating credit VaR.

27. Portfolio Credit Risk

Allan Malz, *Financial Risk Management: Models, History, and Institutions* (Hoboken, NJ: John

Wiley & Sons, 2011). Chapter 8, Sections 8.1, 8.2, and 8.3.

After completing this reading, you should be able to:

a. define and calculate default correlation for credit portfolios.
b. identify drawbacks in using the correlation-based credit portfolio framework.
c. assess the impact of correlation on a credit portfolio and its Credit VaR.
d. describe the use of a single factor model to measure portfolio credit risk, including the impact of correlation.
e. define beta and calculate the asset return correlation of any pair of firms using the single factor model.
f. using the single factor model, estimate the probability of a joint default of any pair of credits and the default correlation between any pair of credits.
g. describe how Credit VaR can be calculated using a simulation of joint defaults.
h. assess the effect of granularity on Credit VaR.

28. Structured Credit Risk

Allan Malz, *Financial Risk Management: Models, History, and Institutions* (Hoboken, NJ: John Wiley & Sons, 2011). Chapter 9.

After completing this reading, you should be able to:

a. describe common types of structured products.
b. describe tranching and the distribution of credit losses in a securitization.
c. describe a waterfall structure in a securitization.
d. identify the key participants in the securitization process and describe conflicts of interest that can arise in the process.
e. compute and evaluate one or two iterations of interim cashflows in a three-tiered securitization structure.
f. describe the treatment of excess spread in a securitization structure and estimate the value of the overcollateralization account at the end of each year.
g. Explain the tests on the excess spread that a custodian must go through at the end of each year to determine the cash flow to the overcollateralization account and to the equity noteholders.
h. describe a simulation approach to calculating credit losses for different tranches in a securitization.
i. explain how the default probabilities and default correlations affect the credit risk in a securitization.
j. explain how default sensitivities for tranches are measured.
k. describe risk factors that impact structured products.
l. define implied correlation and describe how it can be measured.
m. identify the motivations for using structured credit products.

29. Credit Risk

John C. Hull, *Options, Futures, and Other Derivatives, 11th Edition* (Pearson, 2022). Chapter 24.

After completing this reading, you should be able to:

a. assess the credit risks of derivatives.
b. define credit valuation adjustment (CVA) and debt valuation adjustment (DVA).
c. calculate the probability of default using credit spreads.
d. describe, compare, and contrast various credit risk mitigants and their role in credit analysis.
e. describe the significance of estimating default correlation for credit portfolios and distinguish between reduced form and structural default correlation models.
f. describe the Gaussian copula model for time to default and calculate the probability of default using the one-factor Gaussian copula model.
g. describe how to estimate credit VaR using the Gaussian copula and the CreditMetrics approach.

30. Credit Derivatives

John C. Hull, *Options, Futures, and Other Derivatives, 11th Edition* (Pearson, 2022). Chapter 25.

After completing this reading, you should be able to:

a. describe a credit derivative, credit default swap (CDS), total return swap, and collateralized debt obligation (CDO).
b. explain how to account for credit risk exposure in valuing a CDS.
c. identify the default probabilities used to value a CDS.
d. evaluate the use of credit indices and fixed coupons in pricing CDS transactions.

e. define CDS forwards and CDS options.
f. describe the process of valuing a synthetic CDO using the spread payments approach and the Gaussian copula model of time to default approach.
g. define the two measures of implied correlation: compound (tranche) correlation and base correlation.
h. discuss alternative approaches used to estimate default correlation.

STUDY SESSION 6

31. Derivatives

Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital, 4th Edition* (West Sussex, UK: John Wiley & Sons, 2020). Chapter 2.

After completing this reading, you should be able to:
a. define derivatives and explain how derivative transactions create counterparty credit risk.
b. compare and contrast exchange-traded derivatives and over-the-counter (OTC) derivatives, and discuss the features of their markets.
c. describe the process of clearing a derivative transaction.
d. identify the participants and describe the use of collateralization in the derivatives market.
e. define the International Swaps and Derivatives Association (ISDA) Master Agreement, the risk-mitigating features it provides, and the default events it covers.
f. describe the features and use of credit derivatives and discuss potential risks they may create.
g. describe central clearing of OTC derivatives and discuss the roles, mandate, advantages, and disadvantages of the central counterparty (CCP).
h. explain the margin requirements for both centrally-cleared and non-centrally-cleared derivatives.
i. define special purpose vehicles (SPVs), derivatives product companies (DPCs), monolines, and credit derivatives product companies (CDPCs) and describe the limitations of using them as risk mitigating methods.
j. describe the approaches used and the challenges faced in modeling derivatives risk.

32. Counterparty Risk and Beyond

Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital, 4th Edition* (West Sussex, UK: John Wiley & Sons, 2020). Chapter 3.

After completing this reading, you should be able to:
a. describe counterparty risk and differentiate it from lending risk.
b. describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction.
c. identify and describe institutions that take on significant counterparty risk.
d. describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default, and the recovery rate.
e. describe credit value adjustment (CVA) and compare the use of CVA and credit limits in evaluating and mitigating counterparty risk.
f. identify and describe the different ways institutions can quantify, manage, and mitigate counterparty risk.
g. identify and explain the costs of an OTC derivative.
h. explain the components of the X-Value Adjustment (xVA) term.

33. Netting, Close-Out, and Related Aspects

Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital, 4th Edition* (West Sussex, UK: John Wiley & Sons, 2020). Chapter 6.

After completing this reading, you should be able to:
a. explain the purpose of an International Swaps and Derivatives Association (ISDA) master agreement.
b. summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement.
c. describe the effectiveness of netting in reducing credit exposure under various scenarios.
d. describe the mechanics of termination provisions and trade compressions and explain their advantages and disadvantages.

e. provide examples of trade compression of derivative positions, calculate net notional exposure amount, and identify the party holding the net contract position in a trade compression.
f. identify and describe termination events and discuss their potential effects on parties to a transaction.

34. Margin (Collateral) and Settlement

Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital, 4th Edition* (West Sussex, UK: John Wiley & Sons, 2020). Chapter 7.

After completing this reading, you should be able to:

a. describe the rationale for collateral management.
b. describe the terms of a collateral agreement and features of a credit support annex (CSA) within the ISDA Master Agreement including threshold, initial margin, minimum transfer amount and rounding, haircuts, credit quality, and credit support amount.
c. calculate the credit support amount (margin) under various scenarios.
d. describe the role of a valuation agent.
e. describe the mechanics of collateral and the types of collateral that are typically used.
f. explain the process for the reconciliation of collateral disputes.
g. explain the features of a collateralization agreement.
h. differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality.
i. explain aspects of collateral including funding, rehypothecation, and segregation.
j. explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization.
k. describe the various regulatory capital requirements.

35. Central Clearing

Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital, 4th Edition* (West Sussex, UK: John Wiley & Sons, 2020). Chapter 8.

After completing this reading, you should be able to:

a. define a central counterparty (CCP) and describe the mechanics of central clearing.
b. explain the concept of novation under central clearing.
c. define netting, multilateral offset, and compression and provide examples of each.
d. describe the application and estimation of margin and default funds under central clearing.
e. discuss the risks faced by a CCP and the ways it manages its exposures.
f. provide examples of a loss waterfall.
g. explain the different methods of managing the default of one or more members of a CCP.
h. compare bilateral and central clearing.
i. compare initial margin and default fund requirements for clearing members in relation to loss coverage, cost of clearing, and moral hazard.
j. describe the advantages and disadvantages of central clearing.

36. Future Value and Exposure

Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital, 4th Edition* (West Sussex, UK: John Wiley & Sons, 2020). Chapter 11.

After completing this reading, you should be able to:

a. describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective expected positive exposure, and maximum exposure.
b. compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure.
c. identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure.
d. identify typical credit exposure profiles for various derivative contracts and combination profiles.
e. explain how payment frequencies and exercise dates affect the exposure profile of various securities.
f. explain the general impact of aggregation on exposure, and the impact of aggregation on exposure when there is correlation between transaction values.
g. describe the differences between funding exposure and credit exposure.
h. explain the impact of collateralization on exposure and assess the risk associated with the remargining period, threshold, and minimum transfer amount.

i. assess the impact of collateral on counterparty risk and funding, with and without segregation or rehypothecation.

37. CVA

Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital, 4th Edition* (West Sussex, UK: John Wiley & Sons, 2020). Chapter 17.

After completing this reading, you should be able to:

a. explain the motivation for and the challenges of pricing counterparty risk.
b. describe credit value adjustment (CVA).
c. calculate CVA and CVA as a spread with no wrong-way risk, netting, or collateralization.
d. evaluate the impact of changes in the credit spread and recovery rate assumptions on CVA.
e. describe debt value adjustment (DVA) and bilateral CVA (BCVA).
f. explain the distinctions between unilateral CVA (UCVA) and BCVA, and between unilateral DVA (UDVA) and BCVA.
g. calculate DVA, BCVA, and BCVA as a spread.
h. explain how netting can be incorporated into the CVA calculation.
i. define and calculate incremental CVA and marginal CVA and explain how to convert CVA into a running spread.
j. explain the impact of incorporating collateralization into the CVA calculation, including the impact of margin period of risk, thresholds, and initial margins.
k. describe wrong-way risk and contrast it with right-way risk.
l. identify examples of wrong-way risk and examples of right-way risk.
m. discuss the impact of collateral on wrong-way risk.
n. identify examples of wrong-way collateral.
o. discuss the impact of wrong-way risk on central counterparties (CCPs).
p. describe the various wrong-way modeling methods including hazard rate approaches, structural approaches, parametric approaches, and jump approaches.
q. explain the implications of central clearing on wrong-way risk.

38. The Evolution of Stress Testing Counterparty Exposures

Akhtar Siddique and Iftekhar Hasan (eds.), *Stress Testing: Approaches, Methods, and Applications*, (London, UK: Risk Books, 2013). Chapter 4.

After completing this reading, you should be able to:

a. differentiate among current exposure, peak exposure, expected exposure, and expected positive exposure.
b. explain the treatment of counterparty credit risk (CCR) both as a credit risk and as a market risk and describe its implications for trading activities and risk management for a financial institution.
c. describe a stress test that can be performed on a loan portfolio and on a derivative portfolio.
d. differentiate between stressed expected loss and stress loss of a credit portfolio, and calculate the stress loss on a loan portfolio and the stress loss on a derivative portfolio.
e. describe a stress test that can be performed on CVA.
f. calculate the stressed CVA and the stress loss on CVA.
g. calculate the DVA and explain how stressing DVA enters into aggregating stress tests of CCR.
h. describe the common pitfalls in stress testing CCR.

39. An Introduction to Securitization

Moorad Choudhry, *Structured Credit Products: Credit Derivatives & Synthetic Securitization, 2nd Edition* (New York, NY: John Wiley & Sons, 2010). Chapter 12.

After completing this reading, you should be able to:

a. define securitization, describe the securitization process, and explain the roles of participants in the process.
b. explain the terms over-collateralization, first-loss piece, equity piece, and cash waterfall within the securitization process.
c. analyze the differences in the mechanics of issuing securitized products using a trust versus a special purpose vehicle (SPV) and distinguish between the three main SPV structures: amortizing, revolving, and master trust.
d. explain the reasons for and the benefits of undertaking securitization.
e. describe and assess the various types of credit enhancements.

f. explain the various performance analysis tools for securitized structures and identify the asset classes they are most applicable to.
g. define and calculate the delinquency ratio, default ratio, monthly payment rate (MPR), debt service coverage ratio (DSCR), the weighted average coupon (WAC), the weighted average maturity (WAM), and the weighted average life (WAL) for relevant securitized structures.
h. explain the prepayment forecasting methodologies and calculate the constant prepayment rate (CPR) and the Public Securities Association (PSA) rate.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Bouteille and Coogan-Pushner, Chapter 1.

READING 17

FUNDAMENTALS OF CREDIT RISK

Study Session 4

EXAM FOCUS

This reading provides the definition of credit risk and the circumstances under which credit exposure occurs as well as the motivations for taking on or mitigating credit exposure. For the exam, be able to differentiate between the events that give rise to credit risk, and be able to distinguish between insolvency, default, and bankruptcy, which are related but distinct concepts. Also, be able to identify and describe the most common transactions that generate credit risk. Finally, be familiar with the types of entities that are exposed to credit risk (i.e., financial institutions, corporations, and individuals) and what creates credit exposure for the subgroups of these entities.

MODULE 17.1: CREDIT RISK DEFINITION AND TRANSACTION TYPES

LO 17.a: Define credit risk and explain how it arises using examples.

Credit risk is the probability that one party (e.g., a creditor) will lose money if a counterparty fails to honor its financial obligation due to either:

- an inability to repay the obligation,
- an unwillingness to repay the obligation (e.g., due to a dispute), or
- nontimeliness of honoring the obligation.

PROFESSOR'S NOTE

Borrower, obligor, counterparty, and bond *issuer* are typically used synonymously to signify the party receiving funds (credit), which has an obligation to repay it. *Lender*, *creditor*, and *obligee* are primarily used to signify the party providing credit.

Losses often arise when a company borrows funds for capital expansion, but is later unable to repay funds owing to creditors when the obligation becomes due. Losses may also happen because a company's product becomes obsolete (e.g., video cassettes, fax

machines) or under any scenario when an entity is unable to cover its financing costs like interest and principal payments. A nonpayment of obligations generates a credit loss for lenders or creditors. Even if obligations are honored but with a delay, the delay can create credit risk for the creditor as it can lead to lost interest income.

Unanticipated and uninsured events like macroeconomic factors could also cause an entity to miss repaying its obligations, which in turn creates credit risk for its creditors. The most recent example is the COVID-19 pandemic—consider a restaurant that saw a significant decline in service and needed to close, causing it to default on a bank loan that it took out previously to fund its operations or expansion.

Nonpayment of an obligation can also happen due to deliberate actions (e.g., an unwillingness by a borrower to honor its obligation, perhaps because of a dispute around the validity of the original contract). Such disputes may be settled between the two parties, or they may end up in court. An infrequent—but not unusual—example is when a sovereign state chooses to default on its international debt obligations, or force a conversion of its foreign currency debt obligations into domestic currency. This typically creates a credit loss for lenders because of the significant devaluation of the domestic currency following these events. A relatively recent example is the 2002 "pesification" in Argentina.

Generally, the longer the term of the contract, the greater the credit risk is to creditors. In assessing this credit risk, creditors generally want to assess (1) the amount of credit risk, (2) the probability of counterparty default, and (3) the recovery amount and timing of payment receipt.

Insolvency vs. Default vs. Bankruptcy

LO 17.b: Explain the distinctions between insolvency, default, and bankruptcy.

A counterparty's inability to pay its financial obligations can be due to insolvency, default, or bankruptcy.

Insolvency refers to a scenario where a counterparty's liabilities exceed its assets (i.e., it has negative equity). While insolvency and bankruptcy are related, insolvent entities are not necessarily bankrupt.

Default describes a scenario where a counterparty fails to meet its contractual obligations. A common reason for default is the inability or unwillingness to pay when an obligation is due.

Bankruptcy is a legal procedure where an entity, typically in default, seeks legal protection through a court. In a bankruptcy process, the court negotiates with the entity's management, creditors, and other stakeholders. The two forms of bankruptcy are dissolution/liquidation (Chapter 7 in the United States) and restructuring/reorganization (Chapter 11 in the United States).

Transactions That Generate Credit Risk

LO 17.c: Identify and describe transactions that generate credit risk.

Credit risk does not arise solely through traditional lending activities that involve the immediate exchange of money. It can arise out of many more complex activities, including trade transactions involving future payments, derivatives transactions, claims on collateral, and contingent liabilities. In the United States, corporate obligations constitute the largest source of credit exposure, concentrated in domestic financial companies. However, globally, the largest source of credit exposure by notional value is from derivatives—estimated at $600 trillion in June 2020, with most from interest rate derivatives.

The main transaction types that generate credit risk are as follows:

1. *Lending*. When a lender loans funds to a borrower, the lender is exposed to the risk that the borrower will not repay the loan in the future.
2. *Leases*. A lessor (the owner of an asset who often finances the asset with borrowed funds) is exposed to the credit risk that the lessee (the entity using the asset for a period of time) will not make all scheduled lease payments in the future.
3. *Receivables*. If a product or service is sold to a buyer where the buyer has some time (days, weeks, or months) to pay, the seller is exposed to the credit risk of not receiving the payment.
4. *Prepayment*. Prepaying for goods or services exposes the entity making the payment to the risk that the goods or services will not be delivered in the future (e.g., due to the bankruptcy of a company).
5. *Deposits*. Customers are exposed to potential losses (i.e., credit risk) from their banks if they do not have timely access to their bank deposits. Unfortunately, most customers do not evaluate credit risk when choosing a bank. On the other hand, large corporations engage in in-depth due diligence of banks to protect their deposits and minimize credit exposure and risk.
6. *Contingent claims*. Contingent claims are claims that depend on the occurrence of a future event. For example, an insurance policyholder is exposed to the risk that the insurer (insurance company) will not make a payment when a claim is submitted in the future. Similarly, pension plan participants are exposed to the risk that the sponsor's assets are insufficient to meet the fund's liabilities in the future.
7. *Derivatives*. Derivatives create credit risk through indirect exposure to a financial asset, even if no cash flow occurs at the onset. Because each party under a forward or swap agreement could be required to make a payment in the future, each party is exposed to the credit risk of the other party throughout the life of the derivatives transaction. For example, in a currency swap, parties are exposed to the exchange rate fluctuations of two currencies. Other derivatives that give rise to credit risk are repurchase agreements and options.

Figure 17.1 summarizes the credit exposure and loss type relating to the main types of transactions that generate credit risk.

Figure 17.1: Credit Risk Transaction Types

Transaction	Key Credit Exposure	Loss Type
Loans	Slow or no repayment	Interest and face value; time value of money (TVM)
Leases	Nonpayment	Asset recovery; marketing costs
Receivables	Nonpayment	Face value
Prepayments	Slow or no delivery of asset or service	Replacement costs; incremental operating costs; friction costs
Deposits	No repayment	Face value; TVM; friction costs
Contingent claims	Slow or no repayment	Face value; TVM; friction costs
Derivatives	Nonpayment due to default	Replacement costs (i.e., mark-to-market value)

MODULE QUIZ 17.1

1. Which of the following set of factors is most critical in helping creditors assess credit risk?
   A. Amount of credit risk, probability of counterparty default, recovery amount/timing.
   B. Foreign currency exposure, amount of credit risk, amount of illiquid counterparty assets.
   C. Probability of counterparty default, counterparty management strength, recovery amount.
   D. Recovery amount/timing, amount of uninsured assets, probability of counterparty insolvency.

2. Acquaria Corporation's year-end balance sheet shows $280 million in assets and $320 million in debt to creditors. Acquaria's management estimates that it will continue to be able to meet its upcoming payment obligations. The company is best characterized as being:
   A. bankrupt.
   B. insolvent.
   C. in default.
   D. nonperforming.

MODULE 17.2: CREDIT RISK EXPOSURE

LO 17.d: Describe the entities that are exposed to credit risk and explain circumstances under which exposure occurs.

Exposure to credit risk is not inherently bad; it often arises from the daily operating activities of corporations, governments, and other entities, and can even result from the activities of individuals. For example, a tenant prepaying a full year of an apartment lease or a store selling its products on credit exposes them to credit risk. In the United States, the financial sector has the most credit exposure—primarily from the activities of depository institutions and mutual funds, followed by insurance companies, pension plans, and finance companies.

Financial Institutions

Banks

The daily operations of banks expose them to significant credit risk from their individual and corporate borrowers and through their derivatives activities and exposure. Banks tend to be among the most sophisticated institutions in managing credit risk, although the sector's overall risk appetite has declined noticeably in the last few years.

Repurchase agreements and other forms of collateralized lending expose banks to the potential that a counterparty will not repay its obligations or will default. The collateral, which the bank has access to and can sell, mitigates this risk; however, in fast-moving markets, the collateral value may decline and no longer sufficiently cover the amount owed to a bank under the lending contract. Similarly, banks are exposed to counterparty credit risk through their derivatives hedges and portfolio. For example, in 2020, JPMorgan Chase had derivatives receivables credit exposure in excess of $700 billion.

Asset Managers

Asset managers invest client funds to generate returns while meeting their risk objectives, where the objectives vary from low-return, low-risk investments, to high-return-potential, high-risk investments. As a result, asset managers are exposed to credit risk on behalf of their clients. The risk management team of asset managers provides the risk assessment and oversight of the fund managers' investment decisions. A significant amount of the risk management goals is to mitigate these risks by analyzing the creditworthiness of corporate and government entities that issue bond, equity, and other securities.

Hedge Funds

Hedge funds typically have a higher risk tolerance than other investors and have aggressive mandates to invest in risky financial instruments like private equity and debt and alternative investments. They may also sell protection against a decline in a borrower's creditworthiness, or make long and short investments in distressed securities.

Unlike asset managers, hedge fund managers may look at default as an investment opportunity rather than a risk to avoid or hedge. For example, a manager may short sell the debt or equity securities of companies that the manager believes are in significant distress or may default. Exposure does not have to be direct—for example, derivatives like credit default swaps (CDSs) offer significant indirect return potential. Of course, making significant investments in securities that the hedge fund manager expects will decline in value creates significant risk. For example, in 2021, the hedge fund Melvin Capital entered into short sale transactions on GameStop Corp., anticipating a share price decline. When the GameStop share price increased significantly (from $10–$15 to $350), Melvin had to buy back the shares at significantly higher prices than it sold

initially, suffering extremely large losses that resulted in its bailout by other hedge funds to avoid a default.

Insurance Companies

Insurance companies are unique in that they can have credit exposure from multiple aspects of their operations, including underwriting, investments, and reinsurance:

- *Underwriting*. As part of their underwriting activities, insurers collect premiums from policyholders, invest the premiums in a combination of low-risk and high-risk investments, and later pay out claims when losses occur and claims are made. Insurers must balance the goals of generating significant income and long-term returns from investments for shareholders with the goal to minimize risk for policyholders.
- *Investments*. Insurers (e.g., life insurance companies) may manage significant amounts of investments on behalf of their clients in separate accounts. These assets are segregated from the company and do not belong to shareholders; therefore, losses do not impact shareholder returns. However, significant losses could impact the insurer's reputation and could adversely impact future business opportunities.
- *Reinsurance*. A significant portion of an insurance company's risk of policy claims can be transferred to reinsurance companies like Swiss Re and Munich Re under reinsurance contracts. Insurance companies face credit risk from the time lag between when a policyholder submits a claim to when the reinsurer verifies the claim and makes a payment. The more significant the claim, like earthquake- or hurricane-related losses, the greater the credit risk. Further, for certain types of claims, there could be a very long time (often decades) between collecting the premiums and settlement of any claims. The estimated value of these claims is recorded on the insurance company's balance sheet as a reinsurance recoverable because it represents a contingent claim on the reinsurer—and, therefore, a significant source of credit risk for the insurance company.

Pension Funds

Similar to asset managers who invest funds on behalf of their clients, pension funds invest funds on behalf of pension plan members. Investments in credit-risky securities can generate significant credit risk for members. Increasing pension regulation for both private and public pension funds has mandated significant risk management guardrails for these funds to protect plan members.

Corporations

Corporations typically face credit risk from many sources. Most corporations allow customers to pay later for the products they purchase. Changing customer habits, like the significant decline in demand during the recent pandemic for hospitality services or the increasing popularity of online shopping, can create significant losses for corporations. The five main sources of credit risk for corporations are as follows:

1. *Account receivables*. When a corporation sells goods to customers in advance (the customer receives the product today but pays for it later), it creates credit risk for

the corporation because the customer may be unable or unwilling to pay for the product when payment is due. As a result, corporations attempt to assess the credit quality of customers. For large and established corporate customers, this is done relatively easily; however, for smaller corporate customers and for most individuals, this assessment is more difficult. Corporate risk managers often need to assess customer risk based on incomplete data, although they may be able to rely on customer credit scores. Corporations could mitigate receivables credit risk in the following three ways:

   – Buying insurance on their account receivables
   – Selling their receivables to another company (i.e., factoring)
   – Securing foreign transactions through documentary credit (i.e., a form of guarantee that the seller will receive payment)

2. *Short-term investments and bank deposits*. Corporations face credit risk when they invest in short-term securities because the issuer of the security may fail to make good on its interest or principal obligations. Deposits with banks also create credit risk because banks may be unable to pay out deposits when they face significant liquidity distress, generating losses for corporations. Corporations mitigate this risk by diversifying their deposits across several banks.
3. *Derivatives*. Corporations hedge the price risk of the raw materials they need through commodity derivatives, including commodity forwards and futures. Commodity futures create relatively little credit risk because trades are subject to margin requirements and a clearinghouse guarantees performance. However, forwards and swaps are over-the-counter (OTC), nonstandardized contracts that create credit risk on both sides. A counterparty default on a derivatives trade may force a corporation to buy raw materials at a high price on the open market. Corporations that have significant derivatives exposure often have sophisticated risk management functions that analyze and help mitigate risk exposures.
4. *Vendor financing*. Corporations with financing arms that help customers buy on credit or lease their products, called vendor financing, face credit risk from a customer default or nonpayment.
5. *Supply chain*. Corporations that rely on a single supplier for a component of their product face credit risk from the default of the supplier because a default could generate significant losses for the corporation. Corporations that rely on significant shipments from suppliers could also suffer losses if a supplier's goods do not arrive or are lost. For example, the 2021 grounding of a large container ship in the Suez Canal caused billions of dollars in maritime traffic losses.

Individuals

Individuals can also be exposed to credit risk in several ways. The prepayment of goods or services, like prepayment on contracting services or prepaying rent, creates credit risk and could generate a loss if the goods or services are not delivered at a later date. Individuals are also exposed to the credit risk of a bank failure through their bank deposits, and through their investments with asset managers. The risk of losses from

deposits is mitigated in some countries (including in the United States and Canada) through federal deposit insurance.

Managing Credit Risk

LO 17.e: Discuss the motivations for managing or taking on credit risk.

Credit risk arises out of the consequences of company/management decisions—and because the company is in control of these decisions, it represents controllable risk exposure. Understanding how to manage credit risk is critical. Improper risk management can have costly adverse consequences for the company, its managers, and its shareholders more broadly. Successful companies maintain a sufficient equity buffer to absorb some of the anticipated and unanticipated losses, while considering the company's survival, profitability, and return on equity:

- *Survival*. Managing credit risk ensures that companies avoid large losses, and therefore, do not face bankruptcy.
- *Profitability*. Managing credit exposure and avoiding losses will help increase profitability.
- *Return on equity*. Successful companies find the right balance between debt and equity to maximize their return on equity.

MODULE QUIZ 17.2

1. A bank has entered into a $25 million, 6-month repurchase agreement with an investment grade corporate client, collateralized by $26 million notional value, 10-year state bonds. The bank has:
   A. no credit risk because the repurchase agreement matures before the bonds.
   B. no credit risk because the client is rated investment grade; therefore, counterparty default is unlikely.
   C. no credit risk because the notional value of the bonds exceeds the value of the repurchase agreement.
   D. credit risk because if the client defaults, the bank may not be able to sell the bonds to cover the full amount of the repurchase agreement.

2. Which of the following options would a corporation least likely select to mitigate its receivables credit risk?
   A. Factoring.
   B. Insurance.
   C. Derivatives.
   D. Documentary credit.

KEY CONCEPTS

LO 17.a

Credit risk is the probability of losses if a borrower fails to honor its financial obligations. This failure can be due to an inability or unwillingness to repay the obligation, or lack of timeliness to repay.

Factors that could create credit losses include the following:

- An inability to repay obligations following borrowing for capital projects, or due to product obsolescence
- A delay in receiving payment, contributing to lost interest or investment income
- Unanticipated and uninsured macroeconomic events
- Deliberate actions, including a sovereign debt default or forced currency conversion

The longer the term of the contract, the greater the credit risk to creditors. Creditors generally want to assess (1) the amount of credit risk, (2) the probability of counterparty default, and (3) the recovery amount and timing of payment receipt.

LO 17.b

Insolvency occurs when a counterparty's liabilities exceed its assets. Default occurs when a counterparty fails to meet its contractual obligations, either due to an inability or unwillingness to pay. Bankruptcy occurs when an entity seeks legal protection through a court, and the court negotiates with the entity's management, creditors, and other stakeholders. Bankruptcy can take the form of dissolution/liquidation or restructuring/reorganization.

LO 17.c

The main transaction types that generate credit risk are as follows:

- *Lending*. The lender is exposed to the risk that the borrower will not repay the loan in the future.
- *Leases*. The lessor is exposed to the risk that the lessee will not make scheduled lease payments.
- *Receivables*. The seller is exposed to the risk of not receiving payment.
- *Prepayment*. Prepaying for goods or services exposes the entity making the payment to the risk that the goods or services will not be delivered in the future.
- *Deposits*. Customers are exposed to potential credit risk if they do not have timely access to their bank deposits.
- *Contingent claims*. Credit risk may arise from the occurrence of a future event.
- *Derivatives*. Credit risk may arise from indirect exposure to a financial asset.

LO 17.d

The following entities and subgroups are exposed to credit risk under various circumstances.

Financial Institutions

- *Banks* face credit risk through their daily operations, given the potential default or nonpayment of their borrowers. Banks are also exposed to credit risk through collateralized transactions like repurchase agreements because the collateral value may decline and no longer sufficiently cover the amount owed to a bank under the lending contract if the counterparty is unable to pay.

- *Asset managers* are mainly exposed to credit risk on behalf of their clients, given the risk of nonpayment or default of the entities they invest in. This risk is managed through sophisticated risk management teams.
- *Hedge funds* face credit risk through their investments, given the risk of nonpayment or default of the entities they invest in. However, hedge funds often look at credit risk as an investment opportunity and take short positions in distressed company securities or via derivatives like CDSs.
- *Insurance companies* are primarily exposed to credit risk through their underwriting activities, including the risk of not receiving premiums and the risk of losses on their investments. They also face credit risk indirectly through reputational damage from losses in separately managed accounts. Finally, credit risk often arises from reinsurance, given the time lag (which can range from very short to very long) of receiving a payment from reinsurance companies to whom they transferred their policy claims.
- *Pension funds* have credit exposure from investments in credit-risky securities that can generate significant credit risk for members.

Corporations

- *Account receivables*. Credit risk arises because the customer may be unable or unwilling to pay for the product when payment is due. This risk can be mitigated through buying insurance, selling receivables, or using documentary credit.
- *Short-term investments and bank deposits*. The issuer of a short-term security may fail to make good on its interest or principal obligations, while banks may be unable to pay out deposits when they face significant liquidity distress.
- *Derivatives*. Corporations face credit risk, mainly through forward contracts and swaps if a counterparty defaults on a derivatives trade.
- *Vendor financing*. Customers leasing or buying products on credit creates credit risk given a potential customer default or nonpayment.
- *Supply chain*. Corporations that rely on a single supplier for a component of their product face credit risk from the default of the supplier.

Individuals

- Individuals can be exposed to credit risk when they prepay for goods or services and face the risk of not receiving those goods or services in the future. A bank failure through their bank deposits and through their investments with asset managers also generates credit risk. In some countries, deposit insurance mitigates deposit risk.

LO 17.e

Credit risk generally arises due to company decisions—and, therefore, represents controllable risk exposure. Successful companies will do the following:

- Maintain an equity buffer to absorb both anticipated and some unanticipated losses
- Strive to avoid large losses to ensure their long-term survival
- Manage credit exposure with the aim to increase profitability

- Maximize their return on equity by finding the right mix of debt and equity

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 17.1

1. **A** While all factors listed are helpful in assessing credit risk, the three most important factors creditors want to assess are (1) the amount of credit risk, (2) the probability of counterparty default, and (3) the recovery amount and timing of payment receipt. (LO 17.a)

2. **B** Acquaria is best described as being insolvent, meaning its liabilities exceed the value of its assets. Acquaria continues to perform on its contractual obligations. Default occurs when an entity fails to meet its contractual obligations. Bankruptcy occurs when an entity seeks legal protection through a court. (LO 17.b)

Module Quiz 17.2

1. **D** The repurchase agreement exposes the bank to the risk that the client will not repay its obligation or will default. Although the collateral mitigates this risk, in a stressed or unfavorable market, the collateral value may decline and no longer sufficiently cover the amount owed to the bank under the repurchase agreement. (LO 17.d)

2. **C** Corporations typically mitigate receivables credit risk in one of following three ways:
   - Buying insurance on their account receivables
   - Selling their receivables to another company (i.e., factoring)
   - Securing foreign transactions through documentary credit

   (LO 17.d)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Bouteille and Coogan-Pushner, Chapter 2.

READING 18

GOVERNANCE

Study Session 4

EXAM FOCUS

Effective governance provides a framework for achieving an organization's objectives. A key component of effective governance is superior risk management, where risk managers help balance business needs with protecting an organization against undue risks. In this reading, we begin with a general overview of governance and risk management, followed by a detailed examination of the key principles of governance (guidelines, skills, limits, and oversight), transaction parameters, and the role of the credit committee. For the exam, pay particular attention to the management and oversight of guidelines, delegation authority, breaches, and the role of risk management.

MODULE 18.1: GOVERNANCE AND RISK MANAGEMENT

LO 18.a: Define risk management responsibilities in an organization and explain the three lines of defense framework for effective risk management and control.

Effective risk management and control within the governance framework includes the following three lines of defense:

1. **First line of defense.** Business owners who own and manage risks.
2. **Second line of defense.** Enterprise risk management, compliance, and legal functions that monitor and oversee risks and establish policies and procedures. The second line oversees the first line.
3. **Third line of defense.** Internal and external auditors and audit committees who provide independent risk monitoring and assessment.

An organization's chief executive officer (CEO) is responsible for ensuring that adequate governance guidelines have been established. The CEO should have the support of his staff in creating and enforcing robust risk management guidelines.

LO 18.b: Explain the processes that lead to risk taking including credit origination, credit risk assessment, and credit approval processes.

Governance ensures the proper functioning of an organization as well as the detection and mitigation of key risks. Without adequate risk governance, organizations could face losses due to bad judgment by individuals, a breakdown of processes, and/or be exposed to internal or external fraud. The main processes that are involved in risk taking are (1) credit origination, (2) credit risk assessment, and (3) credit approval.

The quality of transactions that are originated will determine an organization's profitability. A portfolio of bad transactions, if not adequately monitored, can create significant losses. Originators are driven by a desire to increase volume and returns/margins, which can lead to higher risk transactions. Adequate risk assessment and credit approval needs to be in place to mitigate these risks.

MODULE QUIZ 18.1

1. To ensure an adequate second line of defense, organizations should:
   A. include the compliance and legal functions in risk oversight.
   B. look primarily to business owners because they own and manage the risks.
   C. ensure that the first line of defense has proper oversight of the second line.
   D. ensure that the audit function provides an independent risk management role.

MODULE 18.2: CREDIT RISK GUIDELINES

LO 18.c: Discuss the following key principles underlying best practice for the governance system of credit risk: Guidelines, Skills, Limits, and Oversight.

Effective governance is based on the following four key principles, which ensure that goals and objectives are achieved, and risks are mitigated:

1. **Guidelines.** Organizations must institute clear guidelines around approvals, including approvals for transactions that give rise to credit risk.
2. **Skills.** Authority must be delegated to those with proper skills.
3. **Limits.** Adequate risk and transaction limits must be set.
4. **Oversight.** Employees and functions should be subject to oversight by qualified and independent people.

Guidelines

Guidelines (i.e., credit policies or risk standards) represent the documents that define the rules for how transactions must be conducted. Guidelines must be understandable, concise, precise, and accessible:

- *Understandable*. Guidelines should be written in a way that is not overly complex and can be easily interpreted. Document language should be clear and straightforward and avoid the complexities and jargon of legal documents.

- *Concise*. Guidelines should be of reasonable length. Users do not appreciate having to read very long documents.
- *Precise*. The goals to be relatively simple and short should not come at the cost of precision. Precision implies that guidelines need to be specific in their language and include real-life scenarios that address how to handle transactions.
- *Accessible*: Guidelines should be easily available on a company's electronic document system. A best practice is to include a 1-to-2-page summary on the company's intranet for easy access.

Creation and Approval

Guidelines help protect organizations against risk. Management is ultimately responsible for the guidelines, and therefore it should ensure that they contain the appropriate authorizations. It is best practice for an organization's chief financial officer (CFO) or chief risk officer (CRO) to sponsor guidelines, which are then ultimately approved by the Board of Directors including one of its risk committees.

Guidelines should be reviewed for content and accuracy periodically, and the content should be up-to-date with current practices and regulations. The Board and its risk committees can request periodic updates on the guidelines to check for quality. Events that cause losses to an organization should trigger a review of the relevant guidelines. Risk managers should consider unlikely but potential hypothetical events and their impact on the organization, such as negative interest rates or negative commodity prices (e.g., the price of oil briefly dipped into negative territory in April 2020 due to a technical issue, causing significant concerns for sellers of oil futures contracts).

Maintenance and Content

The CRO typically owns the guidelines. The CRO's office is responsible for drafting, approving, and maintaining the guidelines. Those drafting guidelines should have sufficient seniority and expertise in the organization and understand the products and markets. Guidelines may pit risk managers against business units and originators, so it is therefore necessary to deal with any conflicts in a professional manner, which can be best handled by those at a more senior level.

As mentioned, guidelines should be reviewed periodically, especially in light of the frequently changing regulatory landscape, with regulations becoming more stringent since 2008. Guidelines may also be modified significantly during notable events in the organization's life, such as mergers and acquisitions.

Guideline topics should include: (1) the purpose of the guidelines, (2) the methodology used, (3) transaction approval flow and delegation of authority, (4) the process on handling new products and markets, (5) the process to review/update the guidelines, and (6) consequences for employees who breach or fail to adequately follow guidelines.

Breach and Noncompliance

Breaches of well-established guidelines should be infrequent. When breaches do occur, they can lead to termination of employment. An organization may tolerate and have

carve-outs for some breaches that occur naturally rather than intentionally, including breaching credit limits due to foreign exchange rate fluctuations.

Organizations typically maintain a central database of transaction exposure and credit parameters, which allows originators to conduct pretrade checks to verify if the contemplated transaction is allowed. This results in an automatic guard against unauthorized trades because the system would either reject the trade or document it as unauthorized.

Skills

Approval

Because it is impractical for the CRO or Board committees to approve all transactions, authorities are delegated down the chain of experienced risk professionals. Risk managers understand that the risk function is often viewed by originators as an impediment to business growth and success. It is therefore important that risk managers and staff understand the business and establish good relations with originators.

Ultimately, risk management does not have approval authority and it is not a profit center. Rather, risk management fulfils an advisory role to the business. Guidelines should clearly describe where input from risk managers is required. While risk managers typically do not have transaction veto rights, there are avenues for expressing dissenting views, often in the form of written memos that are escalated to credit committees.

Delegation of Authority

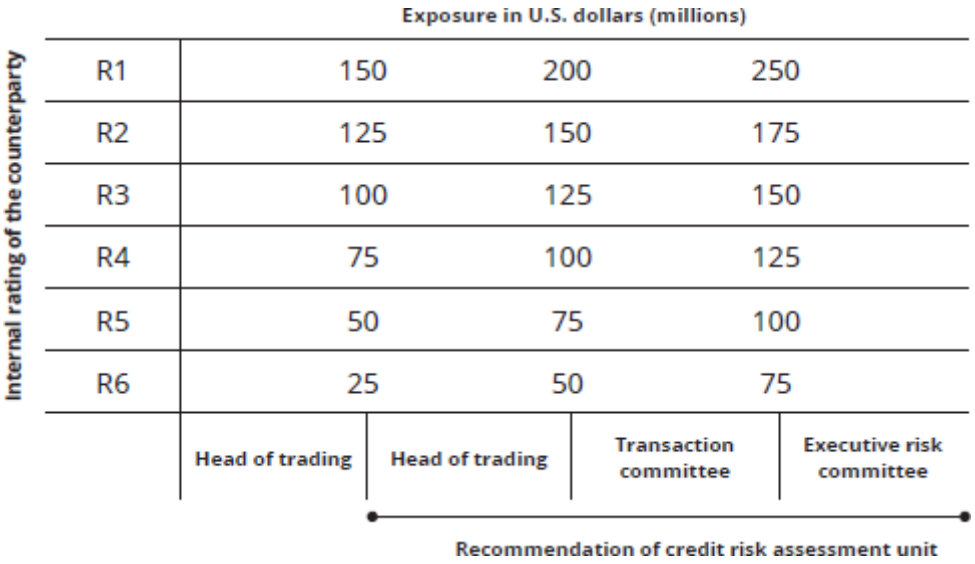
The delegation of authority includes two steps:

1. Assign risk parameters to each transaction.
2. Delegate authority based on those parameters.

Guidelines should clearly establish the approval and delegation process even where it is not practical or possible to assign parameters to transactions. Transaction parameters should include (1) the amount of exposure, (2) credit quality, and (3) tenor (length) of the exposure (see the next LO for more details).

Approval levels should be based on transaction risk. Simpler, low-risk transactions can be approved at lower approval levels, often by a single individual. The riskier the transaction, the higher the approval level needs to be. Senior management is generally involved in transactions that have particularly high risk exposure, are very long, or are of lower credit quality. The approval process is often depicted based on a risk/approval flow, summarizing the escalation of delegation process. An example of this authority delegation process is provided in Figure 18.1.

Figure 18.1: Escalation of Delegation Example



Source: Sylvain Bouteille and Diane Coogan-Pushner, *The Handbook of Credit Risk Management: Originating, Assessing, and Managing Credit Exposures* (2nd Edition, Hoboken, NJ: John Wiley & Sons, 2022). Chapter 2.

Based on this escalation of delegation table, a transaction with an exposure of $110 million with a counterparty rated R4 would require approval by the transaction committee (which has approval for an R4 counterparty up to $125 million). The transaction also requires the recommendation of the credit risk assessment unit (which reviews transactions exceeding $75 million).

Limits

Limits, often called credit lines, represent the maximum loss an organization is willing to accept in absolute dollar terms. For example, a firm may be willing to accept an overall absolute risk limit of $75 million, with smaller limits assigned to individual counterparties, sectors, industries, or even countries. Setting absolute limits works for most types of transactions, although exposure may be difficult to estimate for certain dynamic credit exposures related to long-term trade agreements for physical commodities and derivatives.

Setting risk limits is based on a combination of assessing risk exposures and management's intuition for how much risk is acceptable. This intuition is often based on management experience and feelings. In this case, limits are influenced by what risk regulators, rating agencies, or shareholders find acceptable.

In addition to an aggregate limit at the organization level, limits are also assigned to specific businesses. Originators often prefer to have preapproved limits to facilitate the client marketing process.

Oversight

Effective oversight requires (1) independence, (2) strong qualifications, (3) closeness to the business, and (4) an open mind.

Independence requires that risk management should not be located within or assigned to a profit center, and the compensation of risk managers should be independent of business profitability. To ensure independence, risk management typically reports to the CRO instead of the business unit heads. CROs in most organizations report directly to the CEO, ensuring that the CRO has influence at the top organization level. CROs often have direct access to the Board's risk and audit committees, an increasingly important feature.

While risk managers need to be independent, they should also have a solid understanding of the business units, profit motivations, and transaction structures. In some cases, risk managers may also be asked to attend client meetings in order to adequately articulate an organization's risk position, especially when discussions between the client and originators hit a roadblock due to disagreements on term, price, or limits. When accepting an invitation to a client meeting, a risk manager should have a clear final position based on absolute risk limits, and avoid being influenced by emotions or client pressure. Risk managers should also be mindful of how close they get to business units, because ultimately they need to remain an independent voice regarding risk.

Therefore, a good risk manager needs to balance business needs with protecting the organization's interests. Instead of seeing originators as adversaries, risk managers should help them succeed by facilitating deal closures. Risk managers need to be well qualified for their roles, which allows them to have constructive discussions on transaction risk with originators.

Transaction Parameters

LO 18.d: Describe the most common parameters of a credit-sensitive transaction.

Credit-sensitive transactions can be described by the amount of exposure, credit quality, and length of exposure:

- *Amount of exposure.* Transactions can expose organizations to losses. Measuring the amount of potential losses is critical.
- *Credit quality*. Organizations should assess the risk of losses from transactions with counterparties. Assessing the creditworthiness of counterparties is therefore important.
- *Length of exposure (tenor)*. Organizations should have a good understanding of the period during which they are exposed to potential losses, which is the length of time until an obligation is due by a counterparty.

Credit Committee

LO 18.e: Describe the roles of the credit committee in an organization.

The **credit committee** tends to comprise senior executives and is used for making decisions regarding important or high-risk transactions. The credit committee should

have a charter that clearly lays out the approval processes. The committee makes approval decisions on packages prepared by originators well in advance to give the committee sufficient time to review the information. A well-functioning committee has a track record of approving and declining transactions.

Committee members should have sufficient expertise with a deep understanding of risks, and should include key functions of the organization, including business units, risk management, tax and accounting, compliance, and legal. Members should be individuals tasked with making decisions, with only limited ability to delegate authority. The committee should have a chair who solicits opinions and facilitates the discussion objectively. The chair will direct the committee to a vote if there is no consensus. Meeting minutes should be recorded and distributed shortly after the committee concludes.

MODULE QUIZ 18.2

1. A firm's risk management unit is updating their guidelines relating to transaction approval and delegation. Risk managers are worried that even when transactions fall within available credit limits, foreign exchange volatility may cause breaches in these limits. Which of the following guideline parameters would be most appropriate to deal with this type of outcome?
   A. The guidelines should include a carve-out for breaches that are due to foreign exchange rate volatility.
   B. Breaches in the credit limit due to foreign exchange rate movements should be immediately escalated to the chief risk officer (CRO).
   C. The guidelines should treat each breach in the credit limit as an error by the originator, because currency movements should be anticipated.
   D. Breaches in the credit limit due to foreign exchange rate movements should be immediately escalated to the risk committee of the Board of Directors.

2. Which of the following statements about risk managers' reporting structure is most accurate?
   A. To be most effective, risk managers should report to the business unit heads.
   B. To preserve their independence, risk managers should report directly to the CRO.
   C. Risk managers should have dotted line reporting to both the CRO and business unit heads.
   D. To ensure effective risk governance, risk managers should report directly to the Board of Directors.

3. A firm recently developed a model to help summarize the creditworthiness of each of its counterparties. Which of the following risk parameters of a credit-sensitive transaction does this most likely represent?
   A. Tenor.
   B. Credit quality.
   C. Maximum loss.
   D. Amount of exposure.

KEY CONCEPTS

LO 18.a

Effective risk management and control is based on three lines of defense:

1. *First line*. Business owners who own and manage risks.
2. *Second line*. Enterprise risk management, compliance, and legal functions which monitor and oversee risks.
3. *Third line*. Auditors and audit committees who provide independent risk monitoring and assessment.

LO 18.b

Governance helps an organization function properly by detecting and mitigating key risks. The main processes that lead to risk taking include:

- Origination of transactions.
- Credit risk assessment of key risks.
- Credit approval to mitigate transaction risk and potential losses.

LO 18.c

Effective governance includes four key principles: (1) guidelines, (2) skills, (3) limits, and (4) oversight.

1. Guidelines (i.e., credit policies or risk standards) are documents that define how transactions must be conducted, and should be easily understandable, concise, precise, and accessible.
   - Guidelines should be reviewed periodically. Reviews can be based on specific dates, following major events, large transaction losses, or hypothetical scenarios.
   - The CRO's office is responsible for drafting, approving, and maintaining the guidelines. Guidelines should be written by those who have sufficient seniority and expertise.
   - Guideline topics include: (1) purpose of the guidelines, (2) methodology used, (3) transaction approval flow and delegation of authority, (4) process on handling new products and markets, (5) process to review/update the guidelines, and (6) consequences for breaches.
   - Guidelines should be written to ensure breaches are infrequent. Breaches that an organization can tolerate should include carve-outs.
2. Risk managers and risk functions should have adequate skills in understanding risks, should understand the business, and should establish good relations with originators.
   - Risk management functions in an advisory role to the business. Guidelines should describe where input from risk management is required.
   - Delegation of authority is based on (1) assigning risk parameters to transactions, and (2) delegating authority based on those parameters.
   - Transaction parameters should include the amount of exposure, credit quality, and tenor (length) of the exposure.
   - Approval levels should be based on the level of transaction risk. The riskier the transaction, the higher the approval level should be.

3. Limits (i.e., credit lines) represent the maximum loss in dollar terms that is acceptable to an organization. An organization can have an absolute risk limit, and smaller limits assigned to individual counterparties, sectors, industries, or even countries. Setting risk limits is based on the assessment of risk exposures, and management's experience.
4. Adequate oversight requires independence, adequate qualifications, and an understanding of the business.
   - Risk management should not be located within or assigned to a profit center, and the compensation of risk managers should be independent of business profitability. Risk management typically reports to the CRO who has influence at the top organization level.
   - Risk managers should also have familiarity with the business units, profit drivers, and transaction structures. When risk managers attend client meetings, they should have a clear final position based on absolute risk limits, and avoid being influenced by emotions or client pressure.
   - A good risk manager is able to balance the needs of the business with protecting the organization's interests. Risk managers need to be adequately qualified for their roles.

LO 18.d

Credit-sensitive transactions can be described by (1) the amount of exposure (measuring losses), (2) credit quality (assessing the risk of losses due to counterparty exposure), and (3) length of exposure (period during which risk exposure exists).

LO 18.e

The credit committee, which is made up of senior executives, makes decisions regarding high profile/high-risk transactions. The committee should have a charter detailing the approval processes. It should have a chair who solicits opinions and facilitates discussions objectively. It should also balance business needs with risks, resulting in a combination of approving and declining transactions. Committee members should have solid risk experience.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 18.1

1. **A** Effective risk management and control is based on three lines of defense: first line (business owners), second line (enterprise risk management, compliance, and legal functions), and third line (internal and external auditors and audit committees). The second line provides oversight of the first line. (LO 18.a)

Module Quiz 18.2

1. **A** The firm should include a carve-out in the guidelines to allow for breaches of credit limits due to external factors not within the control of the firm. It is not

prudent to treat these breaches as an originator error, and it is not necessary to escalate them if the guidelines include the carve-outs. (LO 18.c)

2. **B** Risk managers should report to the CRO instead of the business unit heads to ensure they remain independent and free of business influence. CROs have influence at the top organization level including the CEO and risk committees. It would not be feasible for risk managers to report directly to the Board, which deal with broad oversight of risks rather than more granular risk matters. (LO 18.c)

3. **B** Parameters of credit-sensitive transactions include credit quality (assessing the creditworthiness of counterparties and the risk of losses due to counterparty exposure), the amount of exposure (measuring losses), and length of exposure (period during which risk exposure exists). (LO 18.d)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Greuning and Brajovic Bratanovic, Chapter 7.

READING 19

CREDIT RISK MANAGEMENT

Study Session 4

EXAM FOCUS

This topic focuses on how banks manage credit risk exposures, which is a leading cause of bank failures. For the exam, know the key elements that banks should include in their credit risk management policies. Understand the ways to reduce risk in a bank's formal lending policy, the scope of loan portfolio reviews, and the detail needed for loan loss allowances. Also, be able to categorize a loan into one of the five credit asset classification categories. Be familiar with how to calculate expected loss and be able to compare it with unexpected loss. In addition, know the steps in the loan workout process and the balance sheet impact from the two ways to handle loss assets (i.e., retention and write-off). Finally, be aware of what should be included in a credit risk management capacity review.

MODULE 19.1: CREDIT RISK POLICIES AND CREDIT ASSET CLASSIFICATION

Elements of an Effective Lending Policy

LO 19.a: Describe key elements of an effective lending or financing policy.

Credit risk (i.e., counterparty risk) is the chance that a borrower will either make delayed payments or no payments at all. If this risk is not managed well, it can spill over to affect a bank's liquidity. Credit risk is linked to approximately 70% of a bank's balance sheet, which makes credit risk the primary cause of bank failure.

Supervisors and financial analysts expect banks to have formal policies governing their credit risk management process. A lending (or financing) policy should detail the scope of the bank's credit facilities as well as the ways the risk is managed (i.e., origination, appraisal, internal supervision, and collection procedures). Flexibility to adapt to changing conditions is critical. It is also important for risk managers to have access to the Board of Directors if an issue deserves special consideration.

Almost all regulators impose minimum standards for lending policies. These standards cover the identification of existing (and potential) risks, a detailed description of the bank's risk management philosophy, and the establishment of acceptable credit risk parameters. These policies can loosely fit into one of three high-level categories: (1) policies designed to limit or reduce credit risk, (2) policies that classify assets by credit risk exposure and collectability, and (3) policies to create provisions for potential losses.

Setting Exposure and Concentration Limits

LO 19.b: Explain the importance and challenges of setting exposure and concentration limits.

With the goal of limiting credit risk exposures, regulators focus on three core areas: (1) exposure to a single customer, (2) related-party financing, and (3) overexposure to an economic sector or geographic area.

Concentration limits refer to the maximum exposure to a single client, region, or economic sector. Typically, banks will impose limits based on a percentage of bank reserves or capital. Many countries impose a limit of 10%–25% of capital on individual clients. Things get tricky when less-direct forms of credit are involved (e.g., contingent liabilities, guarantees, acceptances, letters of credit). The valuation of collateral is another matter. In practice, collateral should not be considered when sizing risk exposures. A related discussion is the definition of a "single client," which traditionally refers to an individual, entity, or connected group (i.e., a client who is mutually controlled by another, which requires aggregation). The concern is that a large exposure to a single client may bias risk managers in appraising the associated risks. In essence, the bank could end up having a vested interest in the success of a large risk exposure client. Regardless, risk managers need to monitor events affecting large clients independent of whether they are currently meeting their obligations.

Related parties may be able to exert control over bank credit decisions. Examples of related parties include parent companies, subsidiaries, major bank shareholders, affiliated companies, directors, and executive officers. The concern is that credit decisions may be made in violation of the bank's policies and that loan terms may be more favorable than market norms. Most regulators impose a limit based on a percentage of Tier 1 capital. If a local regulator does not impose such a limit, then risk managers should create a comparable policy of their own.

Credit Facility Allocation and Credit Risk Reduction

LO 19.c: Describe the scope and allocation processes of a bank's credit facility and explain bank-specific policies and actions to reduce credit risk.

The scope and allocation of a bank's credit facility should cover how loans are originated, appraised, supervised, and collected. This process should include the

flexibility to adapt to changing market conditions. Several relevant factors related to lending policy and risk reduction are as follows:

- *Lending authority*. Lending policy should establish limits for lending officers. There may be higher limits for lending officers with more experience or longer tenure. This process is often centralized with smaller banks and decentralized (based on geographical area, lending products, or types of customers) for larger banks.
- *Types and distribution of loans*. A bank's lending policy should specify which credit instruments the bank will deploy. This decision should be based on the expertise of the lending officers, the bank's deposit structure, and credit demand. Limitations are commonly imposed for lending categories (i.e., commercial, real estate, consumer, etc.). Any deviations from the limits should require approval of the Board.
- *Appraisal process*. A lending policy can reduce risk by formally defining the appraisal process, including limits on appraisals by credit type, the reappraisal process for renewals and extensions, circumstances requiring independent appraisal, and acceptable limits on the ratio of loan to appraised value.
- *Loan pricing*. Rates on loans should be structured by type with consideration for the cost of funds, loan supervision, and administrative overhead. They should also factor in the probability of loss and a reasonable profit margin for the lender. A lending policy should periodically review rates to adjust to market conditions and the competitive landscape.
- *Maturities*. A lending policy should establish clear maximum maturities for various loan types. These should involve a realistic loan repayment schedule with consideration of the source of funds for repayment and the useful life of the collateral.
- *Exposure to geographic or sector-level concentration*. A substantial risk factor is concentration by geographic region or economic sector. Many banks do not have well-developed systems for monitoring these exposures, but this is essential to understand. This is especially the case for regional or specialty banks. The inclusion of international lending also introduces unique risk factors (e.g., political risk and exchange rate risk).
- *Availability of current financial information*. A lending policy should clearly specify the financial information required for commercial and consumer loans. External credit checks should be involved. It should be determined if business financials need to be audited or not, and financial projections should match the maturity of the desired loan.
- *Monitoring of collections*. Risk management for the lending policy should address the process for dealing with any delinquencies. This should include reporting details to the Board and the process for determining potential losses and alternative plans for repayment.
- *Limits on total loans outstanding*. Policy limits on total loans outstanding should be expressed in relation to capital, deposits, or total assets. The volatility of deposits and known credit risks should also be factored in to reduce overall risk.
- *Maximum ratio of loans to market value of pledged securities*. Margin requirements should be clearly established for all security types. A provision for periodic repricing

of collateral should be included to reduce risk.

- *Impairment recognition*. Loan impairments should be periodically and systematically identified to address loans deemed uncollectable.
- *Renegotiated debt treatment*. Renegotiated debt refers to loans restructured to reduce either interest rates or principal amounts. A loan extension is not considered "renegotiated" in this sense. The restructuring process may involve the introduction of a new debtor, transfer of collateral, or a debt-to-equity swap. A large number of restructurings is an indication that the bank (i.e., the lender) has a serious credit risk issue.
- *Written internal guidelines*. It is very important that all lending policies be properly documented. These cannot be informally understood.

Ultimately, the lending policy builds the bank's loan portfolio. This portfolio should reflect the market demand for loans, the bank's business and risk strategy, and its ability to extend credit. Periodic reviews of the loan portfolio should include a random sample covering:

- at least 75% of the total loan portfolio by dollar amount,
- at least 30% of the number of loans,
- at least 50% of the number of all foreign loans, and
- all loans with a maturity greater than one year.

Additionally, loan portfolio reviews should include the following:

- All loans to single clients whose aggregate exposure for the bank exceeds 5% of bank capital
- All loans to related parties and shareholders
- All loans whose terms have been altered since loan inception
- All loans that are delinquent beyond 30 days
- All loans classified as substandard, doubtful, or loss (discussed in the next section)

Each individual loan review should include detailed documentation about the customer, the loan terms, the use of funds, the structure of any collateral, any noted delinquencies, descriptions of the borrower's financial condition, and an itemization of any monitoring efforts conducted. If the amount borrowed exceeds 5% of the bank's capital, then consideration is given to the associated business plan and debt service capacity. This review should be conducted with input from the assigned credit loan officer.

Risk managers should also periodically review the bank's policy for loan loss allowances. This review should include the following:

- A survey of the existing policy for allowances
- An overview of the asset classification process
- An assessment of the current risk factors that may lead to losses; the focus should be on the current factors that are different from historical ones
- A trend analysis of historical losses

- A statement of the adequacy of the current policy

Interbank deposits and off-balance-sheet commitments should also be considered with respect to credit risk.

Credit Asset Classification

LO 19.d: Discuss factors that should be considered during the credit asset classification process.

Asset classification is the process of assigning bank assets to credit risk grades based on their likelihood of repayment. This is a key tool in credit risk management. Assets should be classified at loan origination and periodically reviewed and reclassified as needed. Review should consider the client's financial condition, loan service performance, economic trends, and any relevant changes in the markets. Regulators breakdown asset classification into the following five categories:

1. *Standard (i.e., pass)*. This label is applied when delinquency is not in question. Loans that are fully secured with cash or cash equivalents (e.g., certificates of deposit) generally maintain this label regardless of other unfavorable credit factors.
2. *Specially mentioned (i.e., watch)*. This category involves assets with potential weaknesses that could impact the borrower's ability to repay. The reasons for this expected weakness are varied.
3. *Substandard*. Loans with well-defined credit weakness that could jeopardize repayment are categorized here. Often, the primary source of repayment has failed, and the bank is already looking to secondary sources (e.g., collateral). Nonperforming loans that have been delinquent for over 90 days are typically categorized as substandard. Some renegotiated loans end up here if interest payments were delinquent before the renegotiation deal materialized. Renegotiated loans can be promoted out of this ranking once sustained performance has been achieved.
4. *Doubtful*. These assets have the same concerns as substandard assets, but the expectation of loss is more pronounced. Nonperforming loans that are over 180 days delinquent will be categorized here unless they are sufficiently secured. There is still some hope for repayment with these assets.
5. *Loss*. When delinquency is relatively certain, a bank should reclassify the loan as a loss. This categorization does not mean that the probability of collection is zero. However, it does mean that it is not practical to delay the write-off process any further. Nonperforming loans that are over one year delinquent will be categorized here unless they are sufficiently secured.

On a very basic level, "nonperforming loans" do not generate any income for the lender (i.e., bank). This term is typically applied when there are no interest or principal payments after 90 days. However, asset classification is about more than just the receipt of payments. It branches into the consideration of the borrower's cash flows

and the expected ability to repay (even with moderate delay). Analysis of nonperforming loans should include the following considerations:

- *Age*. This is how long delinquency has existed (e.g., 30 days, 90 days, 180 days, one year).
- *Reasons*. As with any trouble spot, it is helpful to understand why the trouble is present (i.e., the root cause). It is possible that the bank could help get the borrower back on track.
- *Case-by-case assessment*. Each individual delinquency case should be reviewed, not just in aggregate. Incremental improvements may be possible.
- *Set provision levels*. The bank needs to set thresholds for each classification with consideration of the bank's overall stability.

MODULE QUIZ 19.1

1. Within their credit risk management plan, banks are either required to include, or at least should strongly consider including, a:
   A. classification of risks organized by collectability.
   B. loan loss provisions equal to at least 8% of their loan portfolio.
   C. duration target for the bank's portfolio that is not higher than 10.
   D. rigid set of policies designed to address every possible risk source.

2. A risk analyst is reviewing his bank's credit risk management policies. He notes that banks have limits on related-party financing decisions. His colleague agrees and correctly adds that:
   A. the term *single client* only refers to a legal person.
   B. all banks have a limit of 10% of capital for a single client.
   C. loan collateral should be included in exposure sizing using mark-to-market principles.
   D. acceptances and letters of credit should be factored into the risk exposure of a single client.

3. A regional bank wants to decrease risk in their lending practices. They are considering several lending policy changes. Which of the following items should be included in this new risk-reduction-focused direction?
   A. All loans should have a maximum maturity schedule of 10 years.
   B. The Board should approve all individual delinquency workout plans.
   C. Financial projections from business clients should match the maturity of their loan.
   D. Credit officers should have the flexibility to extend any type of credit that a customer needs as long as they find it to be a reasonable risk for the bank.

4. Three and a half months ago, XYZ Manufacturing lost their single largest customer, and the company stopped service of all debt payments to ABC Bank. The bank has seized some collateral, but they are working with XYZ as they form plans to find new customers and build a better future. For now, the loans to XYZ Manufacturing should most likely be classified as:
   A. loss.
   B. doubtful.
   C. substandard.

D. specially mentioned.

MODULE 19.2: LOAN LOSS PROVISIONING AND CREDIT RISK ASSESSMENT

Loan Loss Provisions and Reserves

LO 19.e: Describe and explain loan loss provisions and loan loss reserves.

The asset classification process enables banks to form **loan loss provisions**, which are resources set aside to offset potential losses in the future. **Loan loss reserves** are accumulated loan loss provisions, over multiple years, that are recorded on the bank's financial statements. Loan loss provisions and reserves are both normally counted as Tier 2 capital. When determining an appropriate reserve, banks should consider the following items:

- Credit quality policies and procedures
- Previous loss exposures
- Growth in the loan book
- Quality of management in charge of lending
- Loan collection and recovery policies
- Changes in the economic environment and business conditions

Expected Loss vs. Unexpected Loss

LO 19.f: Identify and explain the components of expected loss and distinguish between expected loss and unexpected loss.

In the context of loan loss scenarios, **expected loss (EL)** is the anticipated dollar loss if a borrower defaults. This is essentially quantitatively measuring counterparty risk. To fully understand the drivers of expected loss, it is important to understand the three components of EL:

1. **Probability of default (PD).** PD is the likelihood that a specific borrower will fail to make timely payments (i.e., interest and principal) on their loan. Factors contributing to PD are observations from historically similar customers, observed degradation on credit default swaps, information from credit rating agencies, and personalized credit scores for each customer. This measure considers *who* the bank has lent money to.
2. **Loss given default (LGD).** LGD is expressed as a percentage of the capital at risk in the event of a default. In other words, this is the expected percentage loss of the amount borrowed in the event of a default. This measure considers *what product* was used for the credit risk.
3. **Exposure at default (EAD).** EAD is an estimate of the dollar loss exposure of a bank when a borrower defaults. This measure considers *how long* it has been since the

loan was initiated.

Expected loss is computed as follows:

$$EL(\$) = PD(\%) \times LGD(\%) \times EAD(\$)$$

Figure 19.1 illustrates the application of EL for three different borrowers.

Figure 19.1: Expected Loss Components

Borrower	Rating	Loan	PD	LGD	EAD	EL
1	AAA	$1,000,000	0.09%	30.0%	$550,000	$148.50
2	B+	$1,000,000	3.78%	45.0%	$785,000	$13,352.85
3	D (defaulted)	$1,000,000	100.00%	100.0%	$1,000,000	$1,000,000

In a very simplistic way, an **unexpected loss** is a loss that was not captured by the expected loss formula. This type of loss is typically thought of as a tail risk event (i.e., 99th percentile event).

Expected Loss Under IFRS 9

LO 19.g: Explain the requirements for estimating expected loss under IFRS 9.

Before 2018, International Accounting Standard (IAS) 39 required an incurred loss model. Beginning January 1, 2018, International Financial Reporting Standards (IFRS) 9 has switched the requirement to a three-stage expected loss model:

- *Stage 1*. All performing assets (i.e., no delinquency) should have provisions for expected loss calculated using a *12-month* expected loss methodology. This analysis should include effective interest based on the *gross* amount.
- *Stage 2*. Assets with any level of delinquency should use a *lifetime* expected loss model including effective interest based on the *gross* amount.
- *Stage 3*. Nonperforming assets should also use a *lifetime* expected loss model including effective interest based on the *net (carrying)* amount.

Managing Loss Assets

LO 19.h: Describe a workout procedure for loss assets and compare the following two approaches used to manage loss assets: retaining loss assets and writing off loss assets.

The **loan workout procedure** is a very important part of reducing risk for a bank. It is helpful to review historical attempts to collect and the success rate. Each borrower should be considered independently. A common workout procedure may include the following four steps that can be applied in any order:

1. Reduce the bank's credit risk exposure by collecting additional capital, collateral, or guarantees.

2. Work with the borrower to identify areas for potential improvement (e.g., providing advice, developing a plan to reduce costs and increase earnings, selling assets, or restructuring the loan). This option borders on consulting.
3. Introduce a third-party as a possible joint-venture partner or a takeover.
4. Liquidation through out-of-court settlement. This could involve foreclosure, liquidating collateral, or calling on guarantees.

From the perspective of a bank's balance sheet, there are two ways to address loss assets. They are (1) retaining loss assets and (2) writing off loss asset. Retention is common among firms that follow the British tradition. The idea is to allow time for collection attempts to be tried. The retention method will cause the loss reserve on the balance sheet to appear larger. Writing off the loss is common among firms that follow the U.S. model. This model will immediately write off any losses, which removes them from the loan loss reserves account on the balance sheet. This method will make reserves appear smaller in relation to the size of the loan portfolio.

Credit Risk Analysis

LO 19.i: Explain the components of credit risk analysis.

Credit risk analysis should evaluate which lending products are being used, who are the customers, and for how long is money being lent. This analysis should consider the following components:

- A summary of major loan types including details like the number of customers, the average maturity, and the average interest rate charged
- The distribution of the loan portfolio including the number of loans, the amount lent, and segmentation information (e.g., currencies involved, short-term vs. long-term maturities, and represented economic sectors); it is also important to identify the category of borrower (e.g., state-owned, private borrowers, corporations, and retail customers)
- A list of all loans with guarantees from governmental bodies or other entities
- A thorough review of loans by risk classification
- An analysis of nonperforming loans with reference to the associated vintage year

Credit Risk Management Capacity

LO 19.j: Explain the components of credit risk management capacity, and outline key questions that the board of directors of a bank should ask.

The Board of Directors is ultimately responsible for the credit risk management capacity at a bank. Their high-level lending objectives are to make sound loans that are collectible, make profitable loans that benefit shareholders and protect depositors, and meet the legitimate lending needs of society.

Credit risk management capacity reviews should include the following:

- *Lending process*. The lending process should be well organized with clear policies. The key objective is to make loans with an acceptable risk level when compared to the expected returns. This review should cover the origination, appraisal, approval, monitoring, and collection procedures deployed. The volume of credit applications appraised versus approved should be considered for the previous 6–12 months. This review should involve an interview with all midlevel managers, and it should include the following:
  - Sample loan applications, internal credit summary forms, loan files, and internal credit manuals
  - The criteria for loan approval
  - Lending limits at the various levels of bank management
  - The collateral review process including revaluations
  - The people responsible for loan administration and monitoring, including compliance and controls
  - The process for handling exceptions
- *Staffing*. The staff involved in credit origination, appraisal, supervision, and credit risk monitoring should be listed. Information needed includes the number of staff, their ages, their experience (i.e., qualifications), and specific responsibilities. An essential component of this portion of the review is to detail all staff training including frequency and adequacy assessments.
- *Information flows*. Lending information is spread all over a bank. Part of the necessary review is to understand how information makes its way to senior managers, to the Board, and specifically to the risk committee. This information should flow in a timely manner. Is the information accessible? Is the information high quality? Is the information cost effective?

With respect to credit risk management, the Board of Directors should be asking the following:

- Are the bank's loans and deposits priced competitively?
- Are the sources of interest income well diversified?
- How secure is the income from the loan portfolio?
- Do investment returns reflect the level of risk taken?
- Can the bank's liquidity position survive stressed scenarios?
- Which internal rating models are used by the bank?
- Are PD, LGD, and EAD estimates historically accurate?
- How does the bank treat delinquent loans?
- How frequently is the loan portfolio stress tested?
- Are all concentration risks adequately disclosed?
- Does the bank have the required information (e.g., exposure trends, concentration trends, loss provisions, limits and breaches, impairment charges, delinquency trends, and stress testing results)?

MODULE QUIZ 19.2

1. Two senior credit managers are reviewing their bank's loan loss reserve procedures. Which of the following elements is most important when determining the appropriate level of reserves?
   A. Current loan loss reserves.
   B. The bank's experience with previous losses.
   C. The current number of nonperforming loans in aggregate.
   D. A list of all loans that are delinquent for more than 180 days.

2. Which of the following components of expected loss considers the product that was used for the loan?
   A. Unexpected loss.
   B. Loss given default.
   C. Exposure at default.
   D. Probability of default.

3. A bank's loan asset is considered delinquent, but not yet nonperforming. There is a short-term macroeconomic event that is temporarily preventing repayment. According to IFRS 9, which "stage" is required for this specific loan?
   A. Stage 1.
   B. Stage 2.
   C. Stage 3.
   D. Stage 4.

4. A financial analyst for ABC Bank notices that loan loss reserves are fairly small relative to the size of the bank's loan portfolio. He tells his coworker that this is a red flag for him. However, his coworker tells him that there could be an easy explanation that could be cleared up by asking management. The coworker is suggesting that ABC Bank could be following the:
   A. British model and using the retention model for addressing loss assets.
   B. U.S. model and using the write-down model for addressing loss assets.
   C. U.S. model and providing internal consulting to help the borrower enhance their ability to pay.
   D. U.S. model and allowing more time for collection efforts or collateral enhancement to work out.

5. Portfolio-level credit risk analysis should include:
   A. customer segmentation data.
   B. current macroeconomic conditions.
   C. commentary from the credit risk officer.
   D. details on the bank's interest rate hedging policy.

6. The credit risk management capacity review process should include:
   A. staff diversity metrics.
   B. information available to credit loan officers.
   C. a list of all loans denied in the last three months.
   D. timeliness of information flows from loan officers to the Board.

KEY CONCEPTS

LO 19.a

Credit risk (i.e., counterparty risk) is critical for banks to consider because it is a leading cause of bank failures. Banks should have formal policies in place to identify credit risks and determine how they will be managed and classified. Flexibility to adapt to changing credit or market conditions is critical. Regulators impose a series of minimum standards that are focused on limiting or reducing credit risk, classifying assets according to collectability, and establishing adequate loan loss provisions.

LO 19.b

When considering credit risk exposure, regulators are concerned with concentration risk and related-party risk. Concentration risk relates to excessive exposure to a single client, while related-party issues are concerned with potentially extending credit to someone who does not comply with the bank's risk management policies and extending terms that are more favorable than market norms. Limits are (or should be) imposed for both concentration risk and related-party financing risk.

LO 19.c

There are many factors to consider for reducing risks in a bank's lending policy. They include lending authority, types and distributions of loans, the appraisal process, loan pricing, maturities, exposure to geographic or economic concentrations, the availability of current financial information, collections monitoring, limits on total loans outstanding, a maximum ratio of loans to market value of pledged securities, impairment recognition methods, and having written internal documentation detailing all policies. The loan portfolio needs to be periodically reviewed, and there should be a formal process for assessing loan loss allowances.

LO 19.d

Asset classification is beneficial for managing a bank's credit risk. Nonperforming loans need to be identified and possible solutions for each scenario need to be considered. The bank should then set thresholds for each category. The categories include standard (or pass), specially mentioned (or watch), substandard, doubtful, and loss. This spectrum moves from healthy borrowers to those in a small to moderate amount of trouble to those estimated to be in default.

LO 19.e

Loan loss provisions account for the estimated losses for a bank. Loan loss reserves are accumulated provisions on the bank's balance sheet. Loan loss provisions and reserves should consider the economic and business conditions, the bank's own credit policies, the experience level of management in charge of the lending process, previous realized losses, loan growth, and the bank's collection and recovery processes.

LO 19.f

Expected loss is a calculated estimate of loss in the event of a default. It is the product of the probability of default, the loss given default, and the exposure at default. Unexpected loss is any realized loss that is not captured by expected loss modeling.

LO 19.g

IFRS 9 established a new standard for reporting loss effective January 1, 2018. There are three stages used for reporting guidance. If the assets are performing, then use a 12-month expected loss model with effective interest calculated based on the gross amount. If the assets have any level of delinquency, then use a lifetime expected loss model with effective interest calculated based on the gross amount. If the assets are nonperforming, then use a lifetime expected loss model with effective interest calculated based on the net amount.

LO 19.h

The loan workout process is important for a bank to formalize. There are four steps that can be applied in any order. They include (1) collecting additional capital, collateral, or guarantees, (2) consulting with the borrower on ways to improve operations to enable repayment, (3) brokering a takeover or joint-venture partner to enable repayment, or (4) liquidation through an out-of-court settlement.

From the perspective of loan loss reserves on the balance sheet, management can choose two primary methods. The first is retaining the loss assets in the reserves to allow time for collection efforts to work out. The second is to immediately write off the loss asset. The first option will make loan loss reserves on the balance sheet appear much larger than writing off the loss (relative to the size of the loan book).

LO 19.i

Credit risk analysis should consider which lending products are being used, who are the customers, and for how long they are borrowing money. Portfolio-level analysis should include a summary of loan types, a distribution of the key segments of customers, a list of all loans with guarantees, a review of loans by risk classification, and an analysis of nonperforming loans by vintage year.

LO 19.j

Credit risk management capacity reviews should consider the lending process, the bank's staffing, and its flow of information. The end goal of information flow analysis is to make sure that senior managers and the Board have the information they need in a timely manner.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 19.1

1. **A** All banks should have a well-developed series of policies to manage credit risk exposures. Policies should include recognizing and managing known risks. They need to be flexible to adapt to changing conditions. While regulators like to see established loan loss provisions and risk parameters, the specific targets are at the discretion of each bank because risk exposures are unique. (LO 19.a)

2. **D** Credit risk management should consider both related-party financing and concentration limits. The concern with a related-party transaction is either that a

credit decision may be biased, or the loan terms may be more favorable than market norms. Concentration limits should be imposed to protect against overexposure to single client, region, or sector of the economy. Alternative credit (e.g., acceptances, lines of credit, guarantees, etc.) should be factored in as well, but collateral should not be considered when sizing risk exposures. (LO 19.b)

3. **C** Some lending policy practices that reduce risk are matching the length of financial projections to loan maturities, only offering loans that match the bank's targeted products, matching maturity to the type of loan and the source of funds for repayment, and having a formal delinquency workout policy. The Board should be aware of delinquency issues, but they do not need to approve each individual workout plan when a solid policy is in place. (LO 19.c)

4. **C** XYZ Manufacturing is approximately 105 days delinquent on debt service payments. ABC Bank has begun to access secondary sources of capital (i.e., collateral), but XYZ has hope for repayment. There is a path for them to move forward. A renegotiation may be needed down the line, but for now, this loan should be classified as "substandard." They are not as severe as "doubtful" or "loss," and they are a bigger concern than merely being classified as "specially mentioned." (LO 19.d)

Module Quiz 19.2

1. **B** It is important to include the bank's previous experience with loan losses. Loss provisions should not be biased by the number of aggregate losses already on the books (i.e., reserves). Loss provisioning needs to consider the bank's policies at a high level and not focus on classification issues (i.e., the number of days delinquent). If they did factor delinquency, then 180 days is too long. (LO 19.e)

2. **B** The component of expected loss that considers which loan product was used is loss given default (LGD). The probability of default (PD) considers which client is associated with the loan while the exposure at default (EAD) considers how long the loan has been outstanding. (LO 19.f)

3. **B** IFRS 9 requires three stages of reporting. Stage 1 is for performing assets. They can apply a 12-month expected loss methodology using effective interest computed based on the gross amount. Stage 2 is for assets with some level of delinquency. They can apply a lifetime expected loss methodology using effective interest computed based on the gross amount. Stage 3 is for nonperforming assets. They can apply a lifetime expected loss methodology using effective interest computed based on the net amount. (LO 19.g)

4. **B** The U.S. model involves immediate write-down. This method allows for the option of repayment but treats it as unlikely. It will make the loan loss reserves appear smaller on the balance sheet. The British model uses retention of loss assets, which will make the loan loss reserves appear much larger on the balance sheet than the write-off model. While loss assets are retained on the balance sheet, managers give more attention to loss workout options. (LO 19.h)

5. **A** Portfolio-level credit risk analysis should include a summary of major loan types, customer segmentation data, a list of loans with guarantees, a review of loans by risk classification, and an analysis of nonperforming loans. Because this is a portfolio-level analysis, credit officer commentary is not needed. (LO 19.i)

6. **D** The credit risk management capacity review process should include the lending process, staffing, and information flow concerns. Census data should be gathered on staff including the number of people in the risk management function, their ages, their experience, and their specific responsibilities. Diversity metrics may be captured by human resources but not in this review. Within the lending process, it is useful to understand credit applications relative to approvals over the last 6–12 months. The key part of information flow analysis is to understand if accurate, timely, and cost-effective data is making its way to the senior managers and the Board. (LO 19.j)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Schroeck, Chapter 5.

READING 20

CAPITAL STRUCTURE IN BANKS

Study Session 4

EXAM FOCUS

This reading discusses a bottom-up approach to calculating economic capital for credit risk and issues related to that approach. Since a bank holds many assets, we need to examine the expected and unexpected loss in a portfolio setting. The portfolio expected loss is the sum of the individual expected losses; however, portfolio unexpected loss is significantly less than the sum of individual unexpected losses due to diversification effects. We will derive an expression for unexpected loss equal to a fraction of the exposure amount. As you will see, default and credit migration increase the unexpected loss of a risky asset (i.e., a loan). For the exam, be familiar with the calculations of expected loss, unexpected loss, and the risk contribution of each asset in a portfolio. Also, know that economic capital is used to cover unexpected losses.

MODULE 20.1: EXPECTED AND UNEXPECTED LOSS

Credit Risk Factors

LO 20.b: Identify and describe important factors used to calculate economic capital for credit risk: probability of default, exposure, and loss rate.

The **probability of default (PD)**, also referred to as expected default frequency (EDF), is the likelihood that a borrower will default; however, this measure is not necessarily the creditor's greatest concern. A borrower may briefly default and then quickly correct the situation by making a payment or paying interest charges or penalties for missed payments. Creditors must rely on other measures of risk in addition to PD.

The **exposure amount (EA)**, also referred to as exposure at default (EAD), is the loss exposure stated as a dollar amount (e.g., the loan balance outstanding). EA can also be stated as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.

The **loss rate (LR)**, also referred to as loss given default (LGD), represents the likely percentage loss if the borrower defaults. The severity of a default is equally as

important to the creditor as the likelihood that the default would occur in the first place. If the default is brief and the creditor suffers no loss as a result, it is less of a concern than if the default is permanent and the creditor suffers significant losses. Both PD and LR are expressed as percentages. Note that, by definition, LR = 1 − recovery rate (RR). Therefore, the factors that affect the loss rate will also impact the recovery rate.

Expected Loss

LO 20.c: Define and calculate expected loss (EL).

Expected loss (EL) is defined as the anticipated deterioration in the value of a risky asset that the bank has taken onto its balance sheet. EL is calculated as the product of EA, PD, and LR:

$$EL = EA \times PD \times LR$$

This expected loss equation describes the average behavior of a risky asset. Over time, the value of the asset will fluctuate above and below its average level. At maturity, in most cases the asset will not have defaulted; however, a fraction of the time default will occur bringing a significant decrease in value. The EL measure does not capture the variation in the risky asset's value. This variation is referred to as *unexpected loss*.

The unanticipated loss on the risky asset can arise from the incidence of default or credit migration. Default is a positive probability event for even the safest of borrowers. Banks can estimate the likelihood of default using historical data, the method employed by rating agencies. On the other hand, default can be estimated using models based on the "option" view of the firm such as the Merton model (discussed in the next two readings). This approach views the firm as holding a call option with a strike price equal to the value of the outstanding debt. If the value of the firm is less than the value of its debt obligations, the firm will default.

Credit migration denotes the possible deterioration in creditworthiness of the borrower. While a shift in migration may not result in immediate default, the probability of such an event increases. It is also possible for the reverse to occur, that is, the credit quality of the obligor improves over time.

Unexpected Loss

LO 20.d: Define and calculate unexpected loss (UL).

LO 20.e: Estimate the variance of default probability assuming a binomial distribution.

As mentioned, **unexpected loss (UL)** represents the variation in expected loss. The observation that the unexpected loss represents the variability of potential losses can be modeled using the typical definition of standard deviation. If UL_H denotes the unexpected loss at the horizon for asset value V_H, then:

$$UL_H \equiv \sqrt{\text{var}(V_H)}$$

In the following equation, the subscript H will be dropped but be aware that we are focused on the horizon date, H. After some algebra, we derive the following expression:

$$UL = EA \times \sqrt{PD \times \sigma^2_{LR} + LR^2 \times \sigma^2_{PD}}$$

Since we assume a two-state model, the variance of PD is simply the variance of a binomial random variable:

$$\sigma^2_{PD} = PD \times (1 - PD)$$

Further note, the EA term explicitly recognizes that only the risky portion of the asset is subject to default.

PROFESSOR'S NOTE

Do not lose sight of the big picture here. We are merely applying the basic definition for standard deviation based on the terminal value of the risky asset on the horizon date.

It is also worthwhile to examine the multiplier (square root term) in more detail. Notice that each term is at most equal to one so the UL is a fraction of the exposure amount. In addition, in the extreme case where the default ($\sigma^2_{PD} = 0$) and recovery ($\sigma^2_{LR} = 0$) are known with certainty, the unexpected loss equals zero, which confirms that the EL is constant and also known with certainty.

EXAMPLE: Computing expected and unexpected loss

Suppose XYZ Bank has booked a loan with the following characteristics: total commitment of $2,000,000 of which $1,800,000 is currently outstanding. The bank has assessed an internal credit rating equivalent to a 1% default probability over the next year. The bank has additionally estimated a 40% loss rate if the borrower defaults. The standard deviation of PD and LR is 10% and 30%, respectively. **Calculate** the expected and unexpected loss for XYZ Bank.

Answer:

We can calculate the expected and unexpected loss as follows:

$$EL = EA \times PD \times LR$$

Exposure amount = $1,800,000
Probability of default = 1%
Loss rate = 40%

$$EL = \$1{,}800{,}000 \times 0.01 \times 0.40 = \$7{,}200$$

$$UL = EA \times \sqrt{PD \times \sigma^2_{LR} + LR^2 \times \sigma^2_{PD}}$$

$$UL = \$1{,}800{,}000 \times \sqrt{0.01 \times 0.3^2 + 0.4^2 \times 0.1^2} = \$90{,}000$$

The unexpected loss represents 5% of the exposure amount: ($90,000 / $1,800,000).

Portfolio Expected and Unexpected Loss

LO 20.f: Calculate UL for a credit asset portfolio and the UL contribution of each asset under various scenarios of portfolio composition, asset characteristics and size.

As mentioned previously, expected loss on the portfolio, EL_P, is the sum of the expected losses of each asset:

$$EL_P = \sum_i EL_i = \sum_i (EA_i \times LR_i \times PD_i)$$

The calculation of portfolio unexpected loss (UL_P) is more complicated from the cross-terms in the variance formula for an N-asset portfolio:

$$UL_P = \sqrt{\sum_i \sum_j \rho_{ij} UL_i UL_j}$$

where each individual unexpected loss follows the unexpected loss equation discussed previously. In the special case where each $\rho_{ij} = 1$ for $i \neq j$, UL_P = sum of individual unexpected losses. In most cases, UL_P will be significantly less than the sum of individual UL_i.

This equation demonstrates that the risk of the portfolio is much less than the sum of the individual risk levels and illustrates that each asset contributes to only a portion of its unexpected loss in the portfolio. This effect is captured by the partial derivative of UL_P with respect to UL_i. Hence, the **risk contribution (RC)**, also known as the **unexpected loss contribution (ULC)**, is defined as:

$$RC_i = UL_i \frac{\partial UL_P}{\partial UL_i}$$

After differentiation, we see that:

$$RC_i = \frac{UL_i \sum_j UL_j \rho_{ij}}{UL_P}$$

Thus, RC_i isolates the incremental risk of adding asset *i* to the existing portfolio.

For a two-asset portfolio, the risk contributions of each asset are calculated as follows:

$$RC_1 = UL_1 \times \frac{UL_1 + (\rho_{1,2} \times UL_2)}{UL_P}$$

$$RC_2 = UL_2 \times \frac{UL_2 + (\rho_{1,2} \times UL_1)}{UL_P}$$

Together, the two risk contributions will equal the unexpected loss on the portfolio (i.e., $RC_1 + RC_2 = UL_P$).

PROFESSOR'S NOTE

We will demonstrate the calculation of risk contribution shortly.

Diversifiable and Undiversifiable Risk

An asset held in isolation bears both diversifiable (firm-specific) and undiversifiable (market) risk. In a portfolio context, the diversifiable risk is reduced effectively to zero in a large portfolio as the asset-specific risks, both good and bad, cancel each other out. On the other hand, undiversifiable risk is the residual credit risk (i.e., risk contribution) that cannot be diversified away.

The Effect of Correlation

The correlation between bank assets is critical to measuring the potential portfolio loss. Intuitively, as the correlation between assets increases, the bank suffers from **concentration risk**. In this scenario, default on one asset (due to, say, industry effects) spills over to other assets, exacerbating the problem.

It is, therefore, important to have reliable estimates of default correlations. Unfortunately, the practical implementation of this basic concept is challenging for two reasons. First, it is extremely difficult to assess the default correlation between unrelated obligors. Second, even if we were confident in our estimates, the sheer number of necessary calculations is unmanageable. For example, in a portfolio of only 20 assets, 190 correlation pairs are computed; in a portfolio of 100 assets, 4,950 pairs are computed {i.e., [n × (n − 1)] / 2 covariances}.

The following numerical example highlights the impact of the correlation coefficient on expected and unexpected loss. Note the lengthy process based only on a two-asset portfolio.

EXAMPLE: Computing portfolio expected and unexpected loss

Bigger Bank has two assets outstanding. The features of the loans are summarized in Figure 20.1. Assuming a correlation of 0.3 between the assets, **compute** EL_P and UL_P as well as the risk contribution of each asset.

Figure 20.1: Loan Features

	Asset A	Asset B
EA	$8,250,000	$1,800,000
PD	0.50%	1.00%
LR	50.00%	40.00%
σ_{PD}	7.05%	10%
σ_{LR}	25.00%	30.00%

Answer:

Step 1: Compute EL for both assets.

$$EL_A = EA \times PD \times LR$$
$$= \$8{,}250{,}000 \times 0.005 \times 0.50$$
$$= \$20{,}625$$

$$EL_B = EA \times PD \times LR$$
$$= \$1{,}800{,}000 \times 0.01 \times 0.40$$
$$= \$7{,}200$$

Step 2: Compute UL for both assets.

$$UL = EA\sqrt{PD \times \sigma^2_{LR} + LR^2 \times \sigma^2_{PD}}$$
$$UL_A = \$8{,}250{,}000 \times \sqrt{0.005 \times 0.25^2 + 0.5^2 \times 0.0705^2} = \$325{,}333$$
$$UL_B = \$1{,}800{,}000 \times \sqrt{0.01 \times 0.3^2 + 0.4^2 \times 0.1^2} = \$90{,}000$$

Step 3: Compute EL_P.

$$EL_P = \$20{,}625 + \$7{,}200$$
$$= \$27{,}825$$

Step 4: Compute UL_P.

$$UL_P = \sqrt{(325{,}333)^2 + (90{,}000)^2 + (2)(0.3)(325{,}333)(90{,}000)}$$
$$= \$362{,}642$$

Step 5: Compute RC for both assets.

$$RC_A = (325{,}333)\frac{(325{,}333 + 0.3 \times 90{,}000)}{362{,}642} = 316{,}084$$

$$RC_B = (90{,}000)\frac{(90{,}000 + 0.3 \times 325{,}333)}{362{,}642} = 46{,}558$$

$$RC_A + RC_B = \$362{,}642 = UL_P$$

EXAMPLE: Computing portfolio expected and unexpected loss

Using the information provided in the previous example and assuming the correlation between the assets has decreased to 0.1, **compute** EL_P and UL_P.

Answer:

$$EL_P = \$27{,}825$$

$$UL_P = \sqrt{(325{,}333)^2 + (90{,}000)^2 + (2)(0.1)(325{,}333)(90{,}000)} = \$346{,}118$$

Because correlation does not impact each asset individually, the expected loss on the portfolio remains the same. However, the unexpected loss (variation) has decreased to $346,118.

MODULE QUIZ 20.1

1. XYZ Bank is trying to forecast the expected loss on a loan to a mid-size corporate borrower. It determines that there will be a 75% loss if the borrower does not perform the financial obligation. This risk measure is the:

A. probability of default.
B. loss rate.
C. unexpected loss.
D. exposure amount.

2. Which of the following statements about expected loss (EL) and unexpected loss (UL) is true?
   A. Expected loss always exceeds unexpected loss.
   B. Unexpected loss always exceeds expected loss.
   C. EL and UL are parameterized by the exact same set of variables.
   D. Expected loss is directly related to exposure.

3. If the recovery rate (RR) increases and the probability of default (PD) decreases, what will be the effect on expected loss (EL), all else equal?

	RR increase	PD decrease
A.	Increase	Increase
B.	Decrease	Increase
C.	Increase	Decrease
D.	Decrease	Decrease

4. Big Bank has contractually agreed to a $20,000,000 credit facility with Upstart Corp., of which $18,000,000 is currently outstanding. Upstart has very little collateral, so Big Bank estimates a one-year probability of default of 2%. The collateral is unique to its industry with limited resale opportunities, so Big Bank assigns an 80% loss rate. The expected loss (EL) for Big Bank is closest to:
   A. $68,000.
   B. $72,000.
   C. $272,000.
   D. $288,000.

5. Bigger Bank has two assets outstanding. The features of the loans are summarized in the following table. Assuming a correlation of 0.2 between the assets, what is the value of the unexpected loss of the portfolio (UL_P)?

	Asset A	Asset B
Exposure	$5,100,000	$3,600,000
PD	2.00%	1.00%
LR	50.00%	40.00%
σ_{PD}	14%	10%
σ_{LR}	25.00%	20.00%

   A. Less than $300,000.
   B. Between $300,000 and $400,000.
   C. Between $400,000 and $500,000.
   D. Greater than $500,000.

MODULE 20.2: ECONOMIC CAPITAL FOR CREDIT

RISK

LO 20.a: Evaluate a bank's economic capital relative to its level of credit risk.

LO 20.g: Describe how economic capital is derived.

The best estimate of the devaluation of a risky asset is expected loss. However, as previous examples illustrate, the unexpected loss can exceed the expected loss by a wide margin. If the bank holds inadequate reserves, there is a possibility the bank will become impaired. Therefore, it is imperative that the bank hold capital reserves to buffer itself from unexpected losses so it can absorb large losses and continue to operate.

Banks set aside credit reserves in preparation for expected losses. However, for unexpected losses, banks need to estimate the excess capital reserves needed to cover any unexpected losses. The excess capital needed to match the bank's estimate of unexpected loss is referred to as **economic capital**.

The amount of economic capital needed to absorb credit losses is the distance between the unexpected (negative) outcome and the expected outcome for a given confidence level. By knowing the shape of the loss distribution, EL_P, and UL_P, the difference between the expected outcome and the confidence level (typically 99.97%) can be estimated. This difference can then be represented as a multiple of portfolio unexpected loss, which is often referred to as the capital multiplier (CM). With this multiplier, economic capital for the portfolio can be derived as:

$$\text{economic capital}_P = UL_P \times CM$$

Modeling Credit Risk

LO 20.h: Explain how the credit loss distribution is modeled.

When estimating economic capital for credit risk, we are largely concerned with the tail of the chosen loss distribution. Credit risks are not normally distributed and tend to be highly skewed, because maximum gains are limited to receiving promised payments while extreme losses are very rare events. Therefore, in practice, a beta distribution is commonly applied in credit risk modeling. The mass of the beta distribution is located between zero and one, so when modeling credit events, losses are defined between 0% and 100%. This distribution is extremely flexible, and can be symmetric or skewed depending on the values of its shape parameters (i.e., β and α). When these shape parameters are equal, the distribution will be symmetric and its mean and variance will be characterized as EL_P and UL_P, respectively. The tail of the credit loss distribution, however, is more difficult to model. In practice, fitting the tail often involves combining the beta distribution with a Monte Carlo simulation.

LO 20.i: Describe challenges to quantifying credit risk.

The bottom-up risk measurement framework that attempts to quantify credit risk has several limitations:

1. Credits are presumed to be illiquid assets. With a bottom-up approach, credit losses are measured by their risk contribution to the credit portfolio and are not influenced by the correlation among risk factors as they are in liquid markets.
2. Credit risk models used in practice only use a one-year estimation horizon. Ideally, credit risk models should incorporate unexpected and expected changes in credit quality of borrowers that occur over several years; however, in practice, this approach is very difficult.
3. Other risk components (such as operational risk and market risk) are separated from credit risk and, thus, managed and measured in different departments within the bank.

MODULE QUIZ 20.2

1. The type of capital used to buffer a bank from unexpected losses is known as:
   A. economic capital.
   B. regulatory capital.
   C. unexpected capital.
   D. risk-adjusted capital.

KEY CONCEPTS

LO 20.a

A bank must hold capital reserves (i.e., economic capital) to buffer itself from unexpected losses so it can absorb large losses and continue to operate.

LO 20.b

Current measures used to evaluate credit risk are:

- The probability of default (PD), which is the likelihood that a borrower will default.
- The loss rate (LR), which represents the likely percentage loss if the borrower defaults.
- Exposure amount (EA), which can be stated as a dollar amount (e.g., the loan balance outstanding) or as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.

LO 20.c

Expected loss is the product of exposure amount (EA), probability of default (PD), and loss rate (LR):

$$EL = EA \times PD \times LR$$

LO 20.d

Unexpected loss represents the variation in expected loss:

$$UL = EA \times \sqrt{PD \times \sigma_{LR}^2 + LR^2 \times \sigma_{PD}^2}$$

LO 20.e

The variance of the probability of default (PD) assuming a binomial distribution is:

$$\sigma_{PD}^2 = PD \times (1 - PD)$$

LO 20.f

In most cases, UL_P will be significantly less than the sum of individual UL_i.

$$UL_P = \sqrt{\sum_i \sum_j \rho_{ij} UL_i UL_j}$$

For a two-asset portfolio, the risk contributions of each asset are calculated as follows:

$$RC_1 = UL_1 \times \frac{UL_1 + (\rho_{1,2} \times UL_2)}{UL_P}$$

$$RC_2 = UL_2 \times \frac{UL_2 + (\rho_{1,2} \times UL_1)}{UL_P}$$

LO 20.g

The amount of economic capital needed to absorb credit losses is the distance between the unexpected (negative) outcome and the expected outcome for a given confidence level.

LO 20.h

In practice, a beta distribution is commonly used to model credit risk.

LO 20.i

The bottom-up risk measurement framework that attempts to quantify credit risk has several issues given that credits are presumed to be illiquid assets with one-year estimation horizons. In addition, other risk components, such as operational risks and market risks, are managed and measured in different departments within the bank.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 20.1

1. **B** Current measures used to evaluate credit risk include the firm's probability of default, which is the likelihood that a borrower will default, the loss rate, which represents the likely percentage loss if the borrower defaults, the exposure amount, and the expected loss, which, for a given time horizon, is calculated as the product of the EA, PD, and LR. The stated 75% loss if the borrower defaults is the loss rate. (LO 20.b)

2. **D** EL increases with increases in the exposure amount. UL typically exceeds EL, but they are both equal to zero when probability of default is zero. UL has additional variance terms. (LO 20.d)

3. **D** If recovery rates increase, the loss rate will decrease, which will decrease expected loss. If the probability of default decreases, the expected loss will also decrease. (LO 20.b)

4. **D**

$$\begin{aligned} EL &= EA \times PD \times LR \\ &= \$18{,}000{,}000 \times 0.02 \times 0.8 \\ &= \$288{,}000 \end{aligned}$$

(LO 20.c)

5. **C** The following calculations describe the steps to compute the unexpected loss of a portfolio.

Compute UL for both assets.

$$UL = EA \times \sqrt{PD \times \sigma^2_{LR} + LR^2 \times \sigma^2_{PD}}$$

$$UL_A = \$5{,}100{,}000 \times \sqrt{0.02 \times 0.25^2 + 0.5^2 \times 0.14^2} = \$399{,}952$$

$$UL_B = \$3{,}600{,}000 \times \sqrt{0.01 \times 0.2^2 + 0.4^2 \times 0.1^2} = \$160{,}997$$

Compute UL_P.

$$\begin{aligned} UL_P &= \sqrt{(399{,}952)^2 + (160{,}997)^2 + (2)(0.2)(399{,}952)(160{,}997)} \\ &= \$460{,}041 \end{aligned}$$

(LO 20.f)

Module Quiz 20.2

1. **A** It is imperative that a bank hold capital reserves (i.e., economic capital) to buffer itself from unexpected losses so that it can absorb large losses and continue to operate. (LO 20.g)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Doumpos et al., Chapter 1.

READING 21

INTRODUCTION TO CREDIT RISK MODELING AND ASSESSMENT

Study Session 4

EXAM FOCUS

This topic focuses on modeling credit risk and credit risk assessment approaches. For the exam, understand how the probability of default, exposure at default, and loss given default are used for estimating expected credit losses. It is also important to understand how the capital adequacy ratio is calculated, including the elements that influence its parameters. In addition, understand the three primary approaches to assessing the probability of default (i.e., judgmental, empirical, and financial models). Pay attention to the type of model inputs, the drawbacks, and the breadth of application for each approach. Within the category of financial models, be familiar with the Merton model, Moody's-KMV model, the CreditMetrics model, and the CreditRisk+ model. Pay attention to how the model variables are defined and the differences between these models. Finally, be able to calculate the risk-adjusted return on capital (RAROC) and use it to determine whether a loan will be profitable for a bank.

MODULE 21.1: CREDIT RISK MODELING AND REGULATORY FRAMEWORK

Evaluating a Bank's Financial Condition

LO 21.a: Explain the capital adequacy, asset quality, management, earnings, and liquidity (CAMEL) system used for evaluating the financial condition of a bank.

Analytical tools for credit risk management are widely used. One of the most common tools is known as CAMEL (capital, assets, management, earnings, and liquidity). Each of these factors is defined as follows:

- *Capital adequacy*. Regulation establishes a minimum capital reserve that all banks must maintain. This analysis should consider historical and current positioning.

- *Asset quality*. Reviewers examine whether the bank's loans are performing or showing some signs of delinquency. This analysis considers interest rate risk and liquidity risk in relation to the bank's assets.
- *Management*. This portion of the analysis focuses on the quality of the bank's risk management structure. Business strategy, financial performance, and internal controls and policies are all considered.
- *Earnings*. Core earnings should be reviewed. Examiners are specifically looking for the stability of earnings, net interest margin, return on assets, and future earnings potential with an eye for the anticipated impact of stressed economic events.
- *Liquidity*. This category considers both the impact of interest rate risk on the bank's investments and the influence of liquidity risk. The goal is to understand if the bank has the potential for short-term liquidity events that could jeopardize the bank's viability.

Credit Risk Factors

LO 21.b: Describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon.

The primary output from a credit risk model is an estimate of expected loss over a set period of time (usually one year). Expected loss is the product of the probability of default, the exposure at default, and the loss given default:

- **Probability of default (PD)** is the likelihood that a borrower will not make scheduled loan payments. In this context, "default" is considered a payment that is delayed by 90 days or more. This factor is expressed as a percentage.
- **Exposure at default (EAD)** is the risk exposure at time of default. It is expressed as a dollar amount and influenced by the characteristics of the loan. Some loans have a stable principal level, while others (e.g., credit card loans) may have principal levels that fluctuate.
- **Loss given default (LGD)** is the percentage of the loan that is expected to be lost in the event of total default. Recovery rates are a complementary concept where the recovery rate (RR) is equal to 100% minus the LGD%. Borrower characteristics can help inform this estimate. For example, corporate loans may be influenced by the size of the borrower, its business sector, and its overall financial health.

Capital Adequacy Ratio

LO 21.c: Estimate capital adequacy ratio of a financial institution.

Banks should always have enough capital to match the risk of their assets. This amount of capital can be measured using the **capital adequacy ratio (CAR)**:

$$\text{CAR} = \frac{\text{capital}}{\text{risk-weighted assets}} \geq \alpha$$

In this formula, capital refers to both Tier 1 and Tier 2 capital. The **risk-weighted assets (RWA)** measure is the weighted average of the bank's assets with the weight adjusted by risk level. The regulatory minimum level for CAR is denoted by α (e.g., 8% under Basel II and 10.5% under Basel III).

There are two methods for deriving a bank's RWA: (1) the standardized approach and (2) the internal ratings-based (IRB) approach.

1. **Standardized approach.** A supervisory authority can prescribe predetermined weights for various asset categories. This method is easy to deploy, but it is based on data that is external to a given bank. This likely will be costlier for the bank because the weights are set high to adjust for the ambiguity of the approach.
2. **Internal ratings-based (IRB) approach.** The IRB approach is customized to each bank and requires sophisticated modeling using historical data. Internal credit scores can be combined with historical data to estimate the PD and LGD. The RWA is then calculated using an *asymptotic risk factor (ASFR) model*, which assumes the credit portfolio is diversified such that no idiosyncratic risk is left (i.e., only systematic risk remains).

Under the IRB approach, the ASFR model allows capital charges to be calculated on a loan-by-loan basis and then aggregated up to the portfolio level. The RWA for an individual corporate borrower is found by applying the following formula:

$$\text{RWA} = \text{K} \times 12.5 \times \text{EAD}$$

In this formula, *K* is the capital required, which is a function of PD, LGD, loan maturity (*M*), an asset correlation parameter (*R*), and a maturity adjustment (β):

$$\text{K} = \left[\text{LGD} \times \text{N}\left(\frac{\text{N}^{-1}(\text{PD})}{\sqrt{1-\text{R}}} + \text{N}^{-1}(0.999)\sqrt{\frac{\text{R}}{1-\text{R}}}\right) - \text{PD} \times \text{LGD}\right]\frac{1+(\text{M}-2.5)\beta}{1-1.5\beta}$$

Where *N* is the cumulative standard normal distribution function and *N-1* is its inverse. The maturity adjustment (β) is computed as:

$$\beta = [0.11852 - 0.05478\log(\text{PD})]^2$$

The asset correlation parameter, *R*, considers the borrower's dependence on the general state of the economy, and it is set by the Basel Committee. This parameter reflects that:

1. asset correlations decrease as PD increases. This infers that higher PD also means higher idiosyncratic risk potential.
2. asset correlations increase with firm size. In other words, larger firms are more influenced by the broad economy while smaller firms are more likely to default due to idiosyncratic reasons.

The maturity parameter, β, is influenced by both loan maturity and PD. This measure suggests that long-term borrowers are risker than short-term borrowers (i.e., downgrades are more likely for long-term borrowers). This means that capital requirements should increase with maturity. It also reflects that low PD borrowers have higher downgrade potential than high PD borrowers. In other words, maturity adjustments should be higher for low PD borrowers.

The Basel III Accord enhanced risk measurement through several updates. It increased the CAR from the 8% threshold required by Basel II to 10.5%. It added liquidity and leverage requirements. It emphasized counterparty risk specifically for derivatives and securitized products. Additionally, it introduced a new framework for risk management including stress tests for extreme market volatility, model validation, and a testing program to enhance realistic expectations during volatile conditions.

MODULE QUIZ 21.1

1. Which subcomponent of the CAMEL analysis tool is focused on delinquent loans?
   A. Liquidity.
   B. Earnings.
   C. Asset quality.
   D. Capital adequacy.

2. A credit risk analyst is trying to determine the percentage of a loan that is expected to be lost if a specific borrower were to default. Which of the following metrics should he apply?
   A. Loss given default.
   B. Exposure at default.
   C. Probability of default.
   D. Recovery default rate.

3. The internal ratings-based (IRB) approach for calculating a bank's capital adequacy ratio (CAR) has several underlying elements. Which of the following statements relates to the IRB approach?
   A. Idiosyncratic risk is explicitly factored into the model.
   B. Estimates of probability of default are made by regulators.
   C. Maturity adjustments should be higher for borrowers with high probabilities of default.
   D. The maturity parameter reflects that capital requirements should increase with maturity.

MODULE 21.2: CREDIT RISK ASSESSMENT APPROACHES

Predicting Default in Credit Risk Models

LO 21.d: Describe the judgmental approaches, empirical models, and financial models to predict default.

There are three primary approaches for assessing the likelihood of default in credit risk models. They are the judgmental approach, data-driven empirical models, and theory-based financial models. The differences between these methods involve the input data required, their scope, and the range of application.

The **judgmental approach** is also sometimes called the "qualitative approach" or the "expert system." The reason for these alternate names is that this approach primarily relies on qualitative data sourced from experts (e.g., credit risk officers). One common

judgmental approach is known as “5C Analysis” because it covers five core dimensions of a borrower’s creditworthiness:

1. *Character* is the personality of the borrower.
2. *Capacity* is the ability of the borrower to repay in a timely manner.
3. *Capital* considers the amount of the borrower’s own capital that is at risk in the transaction.
4. *Collateral* factors any secondary sources that are guaranteeing the loan.
5. *Conditions* reviews the business environment and any loan-specific characteristics.

Data inputs could be publicly available financial statements or a business plan. They could also relate to the business sector or region in which the borrower operates, the broad market, or the general economy. This breadth of inputs means that a judgmental approach can be used for both consumer and corporate loans.

Judgmental approaches can be very beneficial when adequate historical data is not available for a loan. One example is project finance. Many projects are unique, which makes finding relevant historical comparisons problematic. In this scenario, the experience of a credit analyst can add value to the risk analysis.

However, there are some drawbacks to this approach. While this method typically involves a well-structured and systematic process, it relies on expert judgments rather than empirical theories. With this in mind, it can be difficult to validate the quality of the output, update quickly for changing conditions, or assess how a single borrower may impact the entire credit portfolio. This method is neither transparent nor consistent, but it can be a good option for loan types that are highly unique.

Empirical models use historical data (e.g., loans accepted, rejected, in good standing, and in default) to search for nontrivial patterns in the relationship between the likelihood of default and input variables (i.e., risk factors). Data inputs can be gathered from internal databases or from credit rating agencies (CRAs) and other external data providers. Relevant data points are characteristics of the borrower, loan status (i.e., in good standing or in default), and other external risk factors.

This data-driven approach can harness the power of machine learning (ML) to search for highly complex, nonlinear relationships. Using ML can help identify new risk factors. One such newer risk factor that has recently been identified is corporate governance practices. Inputs from social networks and real-time market information can also be incorporated in this manner.

The empirical approach has the following advantages:

1. Relative to the judgmental approach, it adds transparency and consistency to the process.
2. Both the underlying structure of the model and its predictive power can be empirically validated.
3. A hypothesized relationship can be analytically explored.
4. Market data can be updated in real-time to better adjust to changing conditions.

5. Adjustments can be made for specific sectors of the market.
6. The breadth of data inputs enables this approach to be used for both consumer and corporate loans.

While these advantages are important, there are also some important weaknesses of the empirical method. The reliance on historical data may not properly predict a future outcome. This is especially true during periods of high uncertainty and volatility. Additionally, even though market data can be updated in real-time, not all inputs can be. Financial statement data may only be available on a quarterly basis. This frequency of model review may not provide risk information as quickly as a judgmental approach.

In contrast to empirical models, **financial models** are based on normative economic and financial theory. They are sometimes known as "market models" because of their reliance on financial market data. This reliance means that they can only be used for corporate borrowers, which contrasts with both judgmental and empirical approaches that can be used for either corporate or consumer loans. There are two primary types of financial models:

1. **Structural models.** This method assumes that default is an endogenous process, which is influenced by the firm's internal structural characteristics (e.g., the Merton model).
2. **Reduced-form models.** This method assumes that default is driven by a random exogenous event (e.g., a Poisson jump process). The primary input sources for the credit risk structure are market data on credit derivatives and bonds.

Default Probability Using the Merton Model

LO 21.e: Apply the Merton model to calculate default probability and the distance to default and describe the limitations of using the Merton model.

The **Merton model** is an option pricing model where the capital structure of a borrower is viewed as a call option on the assets of the firm. The shareholders of the borrower are like the buyers of the call and the creditors are the writers. The creditors temporarily "own" a portion of the company, but the shareholders have the right to buy back the loan by paying it off or refinancing.

Consider a simplistic example in which a firm has only one loan outstanding with a face value of L that is maturing at time T. It makes economic sense for the shareholders to pay off the debt only if the market value of the firm (A_T) is greater than its debt. If this were not the case, then the firm's net value would be negative. The net worth of the firm could then be summarized as follows:

$$\max(A_T - L, 0)$$

This formula should look familiar because it is also the terminal payoff formula for a call option with a strike price of L and a terminal price at expiration of A_T. Following this logic, the market value of equity (E) can be derived using the Black-Scholes-Merton option pricing formula as follows:

$$E = AN(d_1) - Le^{-rT}N(d_2)$$

Where *A* is the current market value of the firm's assets, *r* is the risk-free rate, and N(.) is the cumulative distribution function of the standard normal distribution. The formulas that follow show the two instances of N(.) in which σ_A denotes the volatility of asset returns:

$$d_1 = \frac{\ln\left(\frac{A}{L}\right) + \left(r + \frac{\sigma_A^2}{2}\right)T}{\sigma_A\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Additionally, the volatility of equity σ_E can be computed assuming that equity is a function of both assets and time:

$$\sigma_E = \frac{\sigma_A AN(d_1)}{E}$$

In these provided formulas, the unknowns are the current value of assets (*A*) and volatility of asset returns σ_A. All other variables are known, which includes the following:

- Market value of equity (*E*)—the market cap of the borrower
- Volatility of equity (σ_E)—estimated using historical market data
- Time (*T*) until full repayment of the loan
- Face value of the debt (*L*)—in practice, this is often the short-term debt on the borrower's balance sheet
- Risk-free rate (*r*)—the current yield on Treasury bills

The **risk-neutral probability of default**, $N(-d_2)$, is effectively the probability that shareholders will not exercise their option to repay the loan. This analysis assumes that the firm's assets grow at the risk-free rate. For the **real-world probability of default**, the expected return on the firm's assets (μ) is substituted for the risk-free rate (*r*):

$$PD = N\left[-\frac{\ln\left(\frac{A}{L}\right) + \left(\mu - \frac{\sigma_A^2}{2}\right)T}{\sigma_A\sqrt{T}}\right]$$

For this formula to derive a PD estimate, the asset return is required. A common approach is to solve for the market value of equity (*E*) and the standard deviation of equity σ_E using historical market data. Then, define μ as the historical rate of change in the value of assets (*A*). Additionally, the real-world PD estimate can be used to measure the **distance to default (DD)**, which is the number of standard deviations the company's assets are away from the face value of the debt (*L*):

$$DD = \frac{\ln\left(\frac{A}{L}\right) + \left(\mu - \frac{\sigma_A^2}{2}\right)T}{\sigma_A\sqrt{T}}$$

Additional Credit Risk Modeling Approaches

LO 21.f: Compare and contrast different approaches to credit risk modeling, such as those related to the Merton model, Credit Risk Plus (CreditRisk+), CreditMetrics, and the Moody's-KMV model.

As shown in the previous section, the Merton model uses an option pricing model to estimate the PD for a borrower's loans. This financial model presents a very useful calculation, but it only focuses on the short-term debt of the firm. There is a related but alternative model known as **Moody's-KMV Expected Default Frequency (EDF) model**. This model has two key differences from the Merton model. First, rather than using the standardized normal distribution, the Moody's-KMV model uses historical data to develop the distribution of default frequencies. Second, the default point (L) is defined as all short-term debt plus half of the long-term debt. The inclusion of some long-term debt more closely approximates the actual loan obligations of the borrower.

The **CreditMetrics model** computes the PD through peer set analysis (i.e., comparing a borrower to the default records of others). This method uses a rating transition matrix to account for changes in default rates over time. The CreditMetrics method is effectively a mark-to-market model. The primary model inputs include the borrower's credit rating, a transition matrix of credit ratings and default rates, historical recovery rates, and the yield margins in the bond market. Controversially, the credit grades have been assumed to be homogenous. The time horizon for a CreditMetrics analysis is typically one year, but some analysts have used up to 10 years. Another point of controversy is that recovery rates are calculated by considering fixed interest rates, which does not reflect the historical volatility of this key variable. The CreditMetrics formula is shown as follows:

$$PV_{it} = \frac{CF_{it}}{(1 + r_t + s_{it})^t}$$

This equation calculates the value of a bond in credit grade i (PV_{it}). Credit grade i is the assumed credit rating for the next period. This is essentially an adjusted present value formula, at time t, given the cash flows (CF_{it}) (i.e., coupon payments), the risk-free rate (r_t), and the annual risk premium for a loan in credit grade i at time t (s_{it}).

The CreditMetrics model can be used to derive market value estimates for individual nonmarketable loans or for an entire loan portfolio. The overall output generates a distribution of loan value changes over time. The method promotes transparency in credit risk management and can be used across a wide range of financial products. It is important to note that the CreditMetrics method is not a rating tool. It is intended to make credit risk management more systematic by providing risk measures that capture the relationship between individual assets. It evaluates risk, at both the individual loan and portfolio levels, in the following three stages:

1. *Reporting profiles*. CreditMetrics can integrate reports from a wide range of loans including fixed-rate bonds, floating-rate bonds, nonperforming loans, non-interest-bearing loans, letters of credit, and market-based tools like swaps.

2. *Volatility from rating changes and defaults*. The transition matrix explicitly considers the impact of upgrades, downgrades, and defaults. Each rating transition adjusts the assumed risk premium, which influences the estimated value of each loan.
3. *Correlations*. Individual loan valuations are aggregated at the portfolio level. Simple correlation estimates are then made between the volatility of the portfolio's value and the asset price volatility.

Developed by Credit Suisse in 1997, the **CreditRisk+ model** does not account for the capital structure of the borrower because it is not directly related to its default probability (in contrast to Moody's-KMV model). While the CreditMetrics method estimates the influence of all individual loans on a firm, the CreditRisk+ method only considers loans in either bankruptcy or a bad credit scenario. The end result is focusing on negative shocks only with an estimated default frequency that is a continuous random variable. This model estimates the PD to be very small and independent of other credit events. A Poisson distribution is the most appropriate option because it sets the average default rate equal to its variance. The CreditRisk+ method only calculates default events, not credit ratings. This points to one of the key benefits of this approach, which is the small amount of data needed for application.

Risk-Adjusted Return on Capital

LO 21.g: Apply risk-adjusted return on capital (RAROC) to measure the performance of a loan.

Profitability is a significant concern for all businesses. Banks need to consider the risk-reward tradeoff related to the loans accepted. This process is a complement to traditional credit risk analysis. The most used metric in this case is the **risk-adjusted return on capital (RAROC)**, which is a ratio of the income on a loan relative to the capital required to obtain the loan:

$$\text{RAROC} = \frac{\text{loan revenues}}{\text{capital at risk}}$$

A loan is considered to be profitable if the calculated RAROC is higher than the bank's cost of capital. The RAROC numerator is the revenue (i.e., interest and principal repayments) coming from the loan. It explicitly considers the following factors:

- The spread (s) between the loan rate and the bank's cost of capital
- The fees (f) attributable to the loan
- The estimated loan losses (l)
- The associated operating costs (c)
- Relevant taxation (x)

In this context, **loan revenues** can be formalized using the following formula:

$$\text{loan revenues} = \text{loan value} \times (s + f - l - c)(1 - x)$$

The RAROC denominator is the **capital at risk** (i.e., the capital a bank would need to cover the risk of default on the loan in question). One way to quantify capital at risk is

to use the change in value of the loan over an observation period, which is often one year. This is intended to capture the impact of changing interest rates, which is why duration comes into play. It is possible to estimate the change in a loan's value (ΔL) given the loan's value (L), its duration (D), the current interest rate (i), and the estimated change in interest rates (Δi):

$$\Delta L \approx -L \times D \times \frac{\Delta i}{1+i}$$

For example, assume that XYZ Bank has a loan with a value of $1,000,000. There is an associated commission of 0.1%, the spread between the loan's interest rate and the bank's cost of capital is 0.65%, the estimate of operating costs is 0.2%, and their estimated tax rate is 11.1%. This loan is expected to be a performing loan with no risk of default. Given this information, the estimated loan revenue is:

$$\$1,000,000(0.0065 + 0.001 - 0 - 0.002)\ (1 - 0.111) = \$4,889.50$$

Additionally, this loan has a duration of 3.75 and an interest rate of 10.5%. Interest rates are expected to increase by 1.5%. The capital at risk can be estimated using the change in loan value as an approximation:

$$\Delta L = -\$1,000,000(3.75)\left(\frac{0.015}{1.105}\right) = -\$50,904.98$$

In this example, RAROC is equal to 9.61%. As long as the bank's own interest rate is less than 9.61%, then this loan is profitable for the bank:

$$\text{RAROC} = \frac{\$4,889.50}{\$50,904.98} = 9.61\%$$

There is an alternative method for estimating the capital at risk that uses historical values and not market-based metrics like expected changes in interest rates. This method uses the **unexpected loan loss** in the RAROC denominator using the following formula:

$$\text{unexpected loan loss} = \alpha \times \text{LGD} \times \text{EAD}$$

This method considers the loss given default (LGD), the exposure at default (EAD), and an adjustment (α) for unexpected default rates. This adjustment factor is derived from the distribution of historical default rates. If the distribution of default rates is assumed to be normal, then at the 99.5% confidence level, an analyst should set $\alpha = 2.6\sigma$. However, most loan distributions have some degree of skewness. For this reason, it is more common to use a higher value (e.g., 5 or 6) based on the characteristics of the loan.

MODULE QUIZ 21.2

1. A financial analyst and a risk manager are discussing ways to derive the probability of default for a bank's loan portfolio. The analyst says that he prefers models that rely on the perspective of internal experts. The manager adds that while internal experts have good perspectives in the risk management process, she prefers a model that is data-driven and one that can assess loans for both consumer and corporate customers. The analyst and manager are referring to which type of credit risk assessment?

	Analyst	Manager
A.	Financial	Empirical
B.	Judgmental	Financial
C.	Judgmental	Empirical
D.	Endogenous	Financial

2. The Merton model is different from Moody's-KMV Expected Default Frequency approach in two key areas. Which of the following statements refers to one of those differences?
   A. The Merton model factors the market value of the borrower's equity, while Moody's-KMV model uses book value.
   B. The Merton model uses the risk-free rate to calculate the distance to default, while Moody's-KMV model uses a customized value.
   C. Moody's-KMV model uses a default point with short-term debt and half of long-term debt, while the Merton model only uses short-term debt.
   D. The Merton model uses historical data to derive a distribution of default frequencies, while Moody's-KMV model uses standardized expectations.

3. A credit risk manager is looking for a method to estimate default risk that considers volatility, credit scores, and comparisons to similar borrowers to enhance predictions. Which of the following methods should this manager select?
   A. Merton model.
   B. CreditRisk+ model.
   C. CreditMetrics model.
   D. Moody's-KMV model.

4. ABC Bank has a loan with a value of $750,000. There is an associated commission of 0.15%, the spread between the loan's interest rate and the bank's cost of capital is 0.45%, the estimate of operating costs is 0.3%, and their estimated tax rate is 12%. This loan is expected to be a performing loan with no risk of default. Additionally, this loan has a duration of 2.85 and an interest rate of 9.5%. Interest rates are expected to increase by 1.25%. What is this loan's risk-adjusted return on capital (RAROC)?
   A. 4.92%.
   B. 6.01%.
   C. 7.64%.
   D. 8.11%.

KEY CONCEPTS

LO 21.a

The CAMEL system is used as a credit risk management tool. More specifically, this method analyzes capital adequacy, asset quality, management, earnings, and liquidity. The goal is to score each area to provide a view into the bank's credit risk exposure.

LO 21.b

An important part of credit risk modeling is estimating expected losses, which is typically calculated over a one-year time horizon. The subcomponents are the probability of default (PD), the exposure at default, and the loss given default (LGD). The PD is the likelihood that a borrower will end up delinquent for more than 90 days. The exposure at default is the dollar risk exposure at the time of default for a given

borrower. The LGD is the percentage of the loan that is estimated to be lost in the event of a default scenario.

LO 21.c

The capital adequacy ratio (CAR) is an integral part of credit risk management. There are two ways to calculate the CAR. The first way is using standardized weights, which can cause a bank to hold more capital because external (i.e., noncustomized) data is used. The second way uses internal historical data to empirically derive risk-weighted asset (RWA) values. This second method involves estimating PD, LGD, and EAD. Basel III enhances the risk management calculations by increasing the CAR threshold to 10.5% (from 8%), adding liquidity and leverage requirements, emphasizing counterparty risks, and introducing stress testing for extreme market conditions.

LO 21.d

There are three primary approaches to finding the PD. They are the judgmental (i.e., expert), empirical, and financial (i.e., market) models. The judgmental approach relies on the experience of experts to assess the risk of default. The empirical model uses historical data to look for important risk relationships. Machine learning is now involved in this method. Financial models for credit risk modeling include structural models and reduced-form models.

LO 21.e

The Merton model uses option pricing theory to define the PD. and the distance to default for a borrower. A strength of this approach is that it uses observed historical data in the analysis. One noteworthy limitation is that the default point (L) is only defined as the short-term debt of the firm.

LO 21.f

While the Merton model uses option pricing theory with only short-term debt as the default point, Moody's-KMV model uses both short-term debt and half of long-term debt. Moody's-KMV model also uses historical data to personalize a default frequency distribution as opposed to the standardized normal distribution used by the Merton model.

The CreditMetrics model evaluates similar companies that have default in its analysis. This is effectively a mark-to-market model that considers the borrower's credit rating and a transition matrix of default rates for different credit ratings. While the CreditMetrics model includes all loans with a borrower, the CreditRisk+ model discards the use of credit ratings and focuses only on nonperforming loans and firms in bankruptcy. Thus, this model requires less data to operate.

LO 21.g

The risk-adjusted return on capital (RAROC) can be used to estimate if a loan will be profitable for a bank. The RAROC numerator is the estimated revenue from the loan. The RAROC denominator is the capital at risk, which can either be estimated as the

change in loan value given a change in interest rates or as the unexpected loan loss. The goal is for the RAROC to be higher than the bank's own interest rate.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 21.1

1. **C** Asset quality focuses on bank assets that are performing or showing signs of delinquency. Capital adequacy relates to minimum capital reserves as set by regulation. Earnings reviews are focused on core earnings with an emphasis on stability, net interest margin, return on assets, and future earnings potential. Liquidity focuses more on short-term liquidity risk than on longer-term focused interest rate risk although both are considered. (LO 21.a)

2. **A** Expected loss has three subcomponents (probability of default, exposure at default, and loss given default). The probability of default is the likelihood that a borrower is delinquent for more than 90 days. The exposure at default is the expected dollar loss if the loan defaults. The loss given default is the percentage of the loan that is estimated to be lost if a default occurs. (LO 21.b)

3. **D** The IRB approach considers several elements based on the bank's customized historical record. The parameters do not reflect regulatory norms because they are customized to each bank. This approach assumes that the credit portfolio is well diversified and that no idiosyncratic risk remains. The maturity adjustment has two components. First, capital requirements should increase with maturity because the risk of default increases as maturity increases. Second, borrowers with low probabilities of default (PD) should have higher adjustments than high PD borrowers. A borrower with a high PD already has a higher instance of default factored into their estimates. (LO 21.c)

Module Quiz 21.2

1. **C** A judgmental model uses the perspectives of experts to assess the probability of default. It can be applied to both consumer and corporate loans. An empirical model uses historical data to estimate relationships between variables and risk outcomes. This can also be applied to both consumer and corporate customers. The financial model uses market data to detect trends and risk estimates. Because financial market data is the primary input, this method can only be used for corporate customers. (LO 21.d)

2. **C** One key difference is that Merton sets the default point as only short-term debt and Moody's-KMV model adds in half of long-term debt. Another key difference is that Moody's-KMV model uses historical data to derive a personalized distribution of default probabilities, while the Merton model uses standardized normal distribution values. In the distance to default formula, the rate of change in historical assets replaces the risk-free rate, and both models use the market value of equity. (LO 21.f)

3. **C** The CreditMetrics model is the option for peer comparisons. It considers bond issuer credit ratings (unlike the CreditRisk+ model). The Merton model uses option pricing theory to calculate the default rate, but it only considers short-term debt. Moody's-KMV model adds some long-term debt to the theory behind the Merton model, but the CreditMetrics model is the best option due to peer comparison demands. (LO 21.f)

4. **D** The estimated loan revenue is $1,980 and the estimated capital at risk is $24,400.68. This results in a RAROC of 8.11%. As long as the bank's own interest rate is less than this value, then the loan will be profitable.

$$\begin{aligned}\text{loan revenue} &= \$750,000(0.0045 + 0.0015 - 0 - 0.003)(1 - 0.12) \\ &= \$1,980\end{aligned}$$

$$\Delta L = -\$750,000(2.85)\left(\frac{0.0125}{1.095}\right) = -\$24,400.68$$

$$\text{RAROC} = \frac{\$1,980}{\$24,400.68} = 8.11\%$$

(LO 21.g)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Doumpos et al., Chapter 2.

READING 22

CREDIT SCORING AND RATING

Study Session 4

EXAM FOCUS

This topic focuses on credit scoring and rating systems. For the exam, understand the differences between these two systems as well as the four benefits offered by the implementation of these systems. Also, understand the differences between and applications of through-the-cycle and point-in-time assessments. Be aware of how behavioral and profit scoring are used in the context of consumer lending and the innovative introduction of social lending. In addition, there are many details you need to know regarding the credit rating agency process. Pay attention to the details considered for corporate borrowers as well as the overall score/rating development process (i.e., data collection and preprocessing, model fitting, model validation, definition and validation of the risk rating, and implementation). Finally, understand the common criticisms of the credit rating agency process.

MODULE 22.1: CREDIT SCORING AND RATING SYSTEMS

LO 22.a: Compare the credit scoring system to the credit rating system in assessing credit quality and describe the different types of each system.

Lenders, investors, and regulators all need a way to quantify the creditworthiness of a borrower. Smaller businesses and individuals are often graded using a **credit score**, which is a number ranging from 300 to 850. Higher numbers are associated with a higher estimated ability to repay. Larger businesses and governments are typically graded with a **credit rating**, which is a letter-grade tabulation (e.g., AAA, AA, A, BBB). While a rating of AAA is generally the rating showing the strongest expectation of repayment ability, each rating agency can deploy their own lettering system. Some ratings use both uppercase and lowercase letters (e.g., Aaa), and some use pluses and minuses (e.g., BBB+).

There are four primary benefits to using a credit scoring/rating system:

1. Reduces subjectivity in loan evaluation and acceptance

2. Enables analysis in credit risk management (e.g., scenario analysis and stress testing)
3. Promotes transparency and consistency through a common framework
4. Reduces time for and cost of appraisal

Credit scoring/rating systems can be developed either internally or externally. Banks often develop their own proprietary system that they use to accept or reject loans. This system allows banks to use internal historical data and apply an understanding of what has worked well in the past. Credit rating agencies, credit bureaus, and consulting firms may create external scores/ratings. The three external vendors (Standard & Poor's, Moody's, and Fitch) sell credit scores/ratings to credit institutions, corporations, and investors.

The next two sections will underscore the important aspects to consider with respect to credit scoring/rating systems.

Types of Credit Rating Systems

LO 22.b: Distinguish between through-the-cycle and point-in-time credit rating systems.

The Basel Committee on Banking Supervision (BCBS) has distinguished two high-level types of credit rating philosophies as follows:

- **Through-the-cycle approach.** This category is used by major credit rating agencies because it has a long-term orientation. It covers at least one full business cycle. Therefore, the ratings are not updated frequently, which makes them less sensitive to short-term events. Thus, this approach may be best suited for longer-term loans.
- **Point-in-time approach.** This category is primarily used by internal processes at a credit institution or a bank. This approach typically focuses on the current scenario and may widen the time period up to one year. These ratings are more volatile than through-the-cycle assessments because they are heavily influenced by short-term events. The point-in-time method may capture default risk close to real-time. Thus, this approach may be best suited for short-term loans.

Developing Credit Scoring and Rating Models

LO 22.c: Describe the process for developing credit risk scoring and rating models.

Credit scores and ratings can be determined for either a specific issuer (i.e., borrower) or for a specific issuance (i.e., loan/bond). An issuer is most likely to seek a credit score/rating when they need to access capital markets to borrow money.

There are two different scoring methods commonly used:

1. **Behavioral scoring.** This approach applies to consumer loans. It refers to the process of observing the historical financial behavior of existing customers. Behavioral scoring is a short-term measure. Unlike the static nature of standard

credit ratings and scores, behavioral scoring updates in real-time to new behavioral information observed (e.g., payment and purchasing behavior, updated default estimates). This approach may be used with credit limits, managing debt collection, and marketing new products.

2. **Profit scoring.** This approach focuses only on the estimated profitability of a loan. It considers loan pricing, operational decisions, credit risk assessments, and default predictions. There are two types of profit scoring models:
   - *Account-level*. This method calculates profit for each individual account and ignores any connections between multiple accounts.
   - *Customer-level*. This method explicitly considers all accounts owned by a customer. It enables the profit perspective to be aggregated across any accounts associated with a specific customer.

Advances in artificial intelligence (AI) and the fintech industry have enabled **social lending** (a.k.a. peer-to-peer lending), which is a transaction directly between a lender and a borrower without the need for a financial intermediary. Credit decisions can be made very quickly, but credit risk modeling in social lending is still an emerging topic. More needs to be done to understand the risks in this lending channel, which often has higher default rates than intermediated loans. The responsible use of big data and transparency are material concerns with this innovation.

MODULE QUIZ 22.1

1. ABC Bank needs to conduct a risk assessment for a large manufacturing firm that is publicly traded. Which of the following statements regarding this assessment is correct? The bank should use a:
   A. credit score to reduce subjectivity.
   B. credit score to enhance transparency.
   C. credit rating to reduce the cost of appraisal.
   D. credit rating despite the limitations for stress testing.

2. A lender is considering using a through-the-cycle approach when assessing the creditworthiness of a potential borrower. Which of the following statements regarding this approach is correct? This method:
   A. will capture default risk in the best way possible.
   B. should be used if the loan is short-term in nature.
   C. should be used if the loan is long-term in nature.
   D. is a robust option because it relies on internal data only.

3. A risk analyst is considering the best method to generate a credit score that updates in near real-time while considering the payment and purchase history of a customer. Which of the following methods for developing credit risk scoring and rating models should he use?
   A. Behavioral scoring.
   B. Social lending scoring.
   C. Account-level profit scoring.

D. Customer-level profit scoring.

MODULE 22.2: CREDIT RATING AGENCY METHODOLOGIES

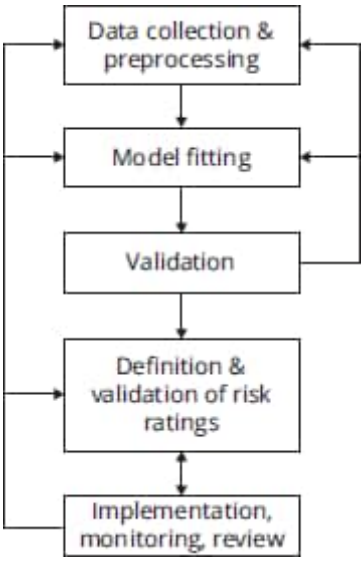
LO 22.d: Describe rating agencies' assignment methodologies for issue and issuer ratings, and identify the main criticisms of the credit rating agencies' ratings.

Credit scoring and rating systems are governed and imposed by regulators and central banks. The Basel Committee has outlined the following five basic specification requirements:

1. *Meaningful differentiation of risk*. There are three subcomponents to this specification. First, credit grades must be established based on risk differences and not as an attempt to manage regulatory capital requirements. Second, borrowers in the same credit grade may be treated differently based on transaction-level differences. Third, there must be a reasonable dispersion across credit grades to avoid concentration in any specific credit grade.
2. *Continuous evaluation of borrowers*. Borrower ratings should be updated on a reasonable basis. In practice, this means no less frequent than an annual rerating review.
3. *Operational oversight*. The goal is to ensure adequate system integrity. The credit scoring/rating system should be continuously monitored for proper functioning, efficient controls (i.e., stress testing), and adequate feedback from associated parties.
4. *Correct selection of risk assessment metrics*. The risk factors analyzed should adequately predict the creditworthiness of the borrower. The goal is to make estimates that are as close as possible to the actual outcomes.
5. *Collecting substantial data*. The data used must represent reality. The credit grading must incorporate historical data, past credit scores/ratings, prior default estimates, and payment history.

Figure 22.1 provides an overview of the rating development process. Each category will be discussed in greater detail in the following sections.

Figure 22.1: Credit Risk Scoring/Rating Development Process



Source: Michalis Doumpos, Christos Lemonakis, Dimitrios Niklis, and Constantin Zopounidis, *Analytical Techniques in the Assessment of Credit Risk: An Overview of Methodologies and Applications* (Springer, 2019). Chapter 2.

Data Collection and Preprocessing

The first step in the credit scoring/rating development process is to collect the appropriate data and consider any data preprocessing needs. The dataset will include performing loans and loans that have been nonperforming for more than 90 days. Some of the data requires preprocessing to eliminate outliers, selecting the most appropriate risk attributes for analysis, and transforming data as needed. Algorithms, statistical tests, and expert judgment will likely be involved in this step.

The data involved in collection and preprocessing will be both quantitative and qualitative. It is important to remove subjectivity from this process and introduce as much consistency as possible. For consumer loans, relevant inputs could include the borrower's income, their assets, any existing loan obligations, their payment history, employment status, use of collateral/guarantees, and the type of loan (i.e., auto loan, credit card, mortgage).

For corporate customers, a different set of information will need to be considered. These factors are discussed as follows:

- *Financial data*. Corporate financial statements (i.e., balance sheet, income statement, and statement of cash flows) are reviewed. Financial ratios are tabulated to better visualize and compare the data. These ratios provide a static view of the firm at a point-in-time as well as their past trend:
  - *Profitability ratios*. The goal is to estimate the ability to repay. These ratios include return on assets (ROA), return on equity (ROE), and profit margins.
  - *Solvency ratios*. The goal is to consider the ability to manage existing debts. These ratios include the current debt load (e.g., debt-to-equity [D/E] ratio) and the ability to repay (e.g., interest coverage).
  - *Liquidity measures*. The goal is to assess the ability to cover short-term obligations. The metrics include working capital, the current ratio, and the quick

ratio.

  - *Management efficiency ratios*. The goal is to measure the operational performance of the firm. These ratios include turnovers for inventories, receivables, accounts payable, and total assets.

- *Transaction data*. While financial ratios are point-in-time estimates, transactions can be reviewed to provide a more updated view of a corporate borrower. This could reflect business transactions or payments made to suppliers or other lenders. This review of borrower behavior could also consider current debt balances, delinquencies, and credit limits.
- *Size and age*. Large firms that are well-established often have a lower default risk than smaller and younger firms. This makes intuitive sense considering access to capital and the ability to absorb adverse events. Market cap is used as the size barometer for publicly traded firms. Total assets or revenues can be used for privately held businesses.
- *Market conditions and competitive position*. An assessment needs to be made of the prevailing market conditions, which are constantly changing. From the perspective of competition, the following questions should be considered:
  - Are there many other competitors? What is the market share of rivals relative to the firm under analysis?
  - Is the market open to new entrants? Do regulations provide any barriers to entry?
  - Is the general outlook for the economy (or sector) favorable?
  - Does the firm have a competitive edge in technology, supply chain access, or some other key resource?
  - Do the firm's suppliers have any level of control over the firm in question?
- *Financial market data*. Publicly traded firms can offer real-time, market-based data like stock prices, volatility of return data, and valuations (e.g., price-to-earnings, price-to-book, earnings per share). Financial market data is best for shorter-term periods and accounting data is better for longer-term loans.
- *Corporate governance*. Several studies have shown that understanding managerial oversight and ethical standards is an important value-added review for corporate success. Items considered include Board of Directors composition and independence, qualifications of top executives, accountability, and protection of shareholder rights.
- *Corporate news and analytics*. An emerging area of consideration is the vast array of available news. This includes press releases, mainstream media, social media, and alternative media sources. There is a tremendous amount of information available that could provide an edge in evaluating a borrower's creditworthiness when done responsibly.

Model Fitting

The second step in the process is **model fitting**, which involves identifying model parameters with the best descriptive ability (i.e., fit) for the model training data. Assume the following linear model:

$$f(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n$$

In this formula, the vector $\beta = (\beta_0, \beta_1, \ldots, \beta_n)$ includes a constant term (β_0) and a series of coefficients $(\beta_1, \ldots, \beta_n)$ for various risk attributes. The goal is to provide the best fit (i.e., optimized estimates for β) such that:

$$\beta^* = \arg\min_{\beta \in \mathbb{R}} L(\beta, X)$$

In this general optimization problem, β^* is the optimal parameter vector and *L* is a loss function representing the difference between the model's output and classification in the training data. This is an empirical proxy for the true problem, which is to minimize default losses. This formula is a regression-like process with a binary (e.g., default/nondefault) dependent variable rather than a continuous variable normally used in standard regression models. Using algorithms, model fitting can involve statistical tools, data mining, and operations research techniques.

Model Validation

The next step in the process is **model validation**, which checks the fitted model against a new sample (i.e., the validation data) not included in the model training data. In other words, this is an out-of-sample test. The validation data should have the same risk attributes as the training data, but use different cases (i.e., borrowers/loans). This process involves statistical tests, like backtesting, using both out-of-sample and out-of-time tests. Both are critical, because if the validation step does not provide good results, then either model fitting or data collection and preprocessing need to be repeated with different variables. The first three steps in the credit scoring/rating development process (i.e., collection/preprocessing, fitting, and validation) often require multiple iterations to achieve success.

To further enhance the validation step, analysts often use **walk-forward testing**, which is a systematic process of rotating forward the time period under evaluation. Testing period *t* involves data beginning at *t–1* and *t–2*. The observation window moves forward for one time period. The new *t+1* testing period includes periods *t*, *t–1*, and *t–2*. Further enhancement can be made using resampling techniques (e.g., bootstrapping and cross-validation).

Benchmarking is an alternative to backtesting, and it involves comparing a credit model's output to an external source (e.g., the rating already published by a credit rating agency). In contrast to the quantitative nature of model fitting and validation, this approach is qualitative. The goal of benchmarking is not to replicate the existing credit rating. Instead, it is to identify any deviation and then seek to understand why it exists. The reason for the deviation may require recalibration and model improvement.

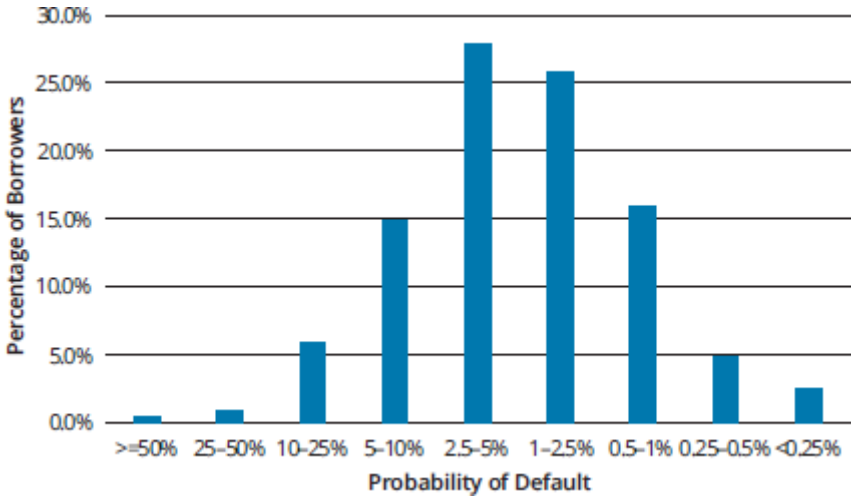
Definition and Validation of Ratings

After data collection/preprocessing, model fitting, and model validation, the derived credit scores should be mapped to a risk rating class. Each rating class should be associated with empirical probability of default (PD) estimates. In addition, each rating

class should be well-diversified relative to its neighboring class, and the distribution of borrowers in the class should not be highly concentrated in a single risk grade.

Consider Figure 22.2, which provides an example distribution of borrowers given their level of risk. In this example, borrowers are organized into nine risk grades. The lowest risk has less than a 0.25% PD and the highest risk has more than a 50% PD. The middle four risk grades have the highest concentration with two of them having over 25% concentration of borrowers. This is considered an acceptable risk concentration (i.e., no excess concentration).

Figure 22.2: Example Distribution of Borrower Risk Grades



This mapping process should also be checked for consistency over time given that rating migration is a concern. If this grouping does not produce adequate results, then the process needs to be re-evaluated and adjusted.

Implementation, Monitoring, and Review

The last stage in the process is implementation, monitoring, and review. At this point, the credit scoring/rating system that was developed will be used to derive real-time risk estimates for loan applications. The system should be continuously monitored, reviewed, and recalibrated as needed. The risk management focus should be on identifying any observed degradation in the quality of the generated risk estimates.

Criticisms of Credit Rating Agency Scores

Common criticisms of credit rating agency (CRA) scores/ratings include the following:

- *Lack of transparency*. The process underlying any rating agency's system is typically proprietary. Therefore, the fairness and validity of the model cannot be publicly verified.
- *Potential conflicts of interest*. It is understood that CRAs harvest fees from the entities for which they are providing a rating. This presents a potential conflict of interest.
- *Promoting a debt explosion*. The work of CRAs has enhanced risk management at lending institutions. This has led to reduced risk premiums. Lower borrowing costs

make debt more accessible, which may increase systemic risk due to credit bubbles and crunches.

- *Poor predictive ability*. The CRAs have collectively done a poor job of predicting recent credit failures. Examples include Enron, WorldCom, and Lehman Brothers. Several empirical studies have found CRA scores/ratings to be less predictive of default than accounting and market-based methods.
- *Procyclicality*. CRAs claim that their models are based on the through-the-cycle approach. The idea is that the ratings should be unaffected by movement through the business cycle. In practice, it has been observed that ratings are often too optimistic during periods of economic growth and too pessimistic during recessions. This suggests some level of procyclicality.

Despite these common criticisms, credit scores/ratings provided by CRAs add useful information for investors and lenders to consider. This should be a complementary part of overall credit risk analysis.

MODULE QUIZ 22.2

1. Moody's is considering a revision to their credit rating model. When they checked the model derived from model training data against out-of-sample data, they found a few issues to address. Which of the following steps in the credit rating development process were they likely on when they noticed this issue?
   A. Model fitting.
   B. Preprocessing.
   C. Model validation.
   D. Validation of the risk rating.

KEY CONCEPTS

LO 22.a

Credit scoring systems feature a three-digit numeric code ranging from 300 to 850. They are typically used to show the creditworthiness of small businesses and individual borrowers. Credit ratings are a lettered code (e.g., AAA, AA, A, BBB) used for larger firms and governments. These models may be developed internally or externally. There are four primary benefits to using these methods, including reduced subjectivity, reduced time/cost for appraisal, enabling analytical tests, and promoting transparency and consistency.

LO 22.b

There are two high-level types of credit rating philosophies. Through-the-cycle approaches are long-term in nature and capture an entire business cycle. They are primarily used by credit ratings agencies, and they are best suited for long-term loans. Point-in-time approaches are used internally by banks and credit institutions. They are short-term in nature, which means they will capture risk events and possibly default risk in almost real-time. This method is best suited for loans that are short-term in nature.

LO 22.c

Credit scores for consumers may be tabulated using either a behavioral or a profit scoring approach. The behavioral method uses historical data to derive a credit score using the customer's behavior (e.g., payments, purchases, personalized default estimates). Using internal data enables scores to adjust in almost real-time.

The profit scoring method ignores customer behavior and instead focuses only on the profitability of the lending relationship. One option is to consider profitability at the account-level and the second is consideration at the customer-level. The recent innovation of social lending also has scoring implications. This is an emerging area that will need further evolution in scoring methods.

LO 22.d

The credit rating agency score/rating development process is complex and data intensive. Different inputs are used for individual borrowers versus corporate clients. The process involves the following five steps:

1. Data collection and preprocessing
2. Model fitting
3. Model validation
4. Definition and validation of the risk rating
5. Implementation

The first three steps may be performed multiple times as the process seeks reliable output. Monitoring, which is inherently involved in the implementation stage, may also produce a need for re-evaluation.

There are five common criticisms for credit rating scores/ratings. They include a lack of transparency, the related potential for conflicts of interest, promotion of higher debt loads, poor predictive ability, and procyclicality.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 22.1

1. **C** Borrowers that are large firms (especially those that are publicly traded) should use credit ratings. Smaller firms and private individuals should be assessed using credit scores. The advantages to using credit scores/ratings include reduced subjectivity, reduced time/cost of appraisal, enabling analysis (e.g., scenario analysis or stress testing), and promoting transparency and consistency. (LO 22.a)

2. **C** Through-the-cycle approaches are used by credit ratings agencies, not by internal models. They consider data from an entire business cycle, which is long-term in nature. For this reason, this method is best suited for long-term loans. Point-in-time assessments use short-term data, and they capture real-time default risk better than the long-term focused through-the-cycle approach. (LO 22.b)

3. **A** Behavioral scoring updates a credit score in near real-time with factors such as a customer's payments, purchases, and probability of default. The two profit scoring approaches (account-level and customer-level) offer different vantage points on a method focused on profitability rather than on the behavior of a customer. Social lending is an emerging innovation with a credit risk scoring system still in its infancy. (LO 22.c)

Module Quiz 22.2

1. **C** The credit score/rating process has five steps: (1) data collection and preprocessing, (2) model fitting, (3) model validation, (4) definition and validation of the risk rating, and (5) implementation. Step 3, model validation, involves checking the model developed in Step 2 with out-of-sample data. (LO 22.d)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Crouhy, Galai, and Mark, Chapter 9.

READING 23

CREDIT SCORING AND RETAIL CREDIT RISK MANAGEMENT

Study Session 4

EXAM FOCUS

This reading examines credit risk management, primarily from the perspective of the retail credit lender. For the exam, focus on the risks incurred by a lender and how credit scoring models can be used to incorporate variables into an effective risk evaluation model. While estimating risk and evaluating model performance is critical, assessing credit applicants for potential profitability is also important. Be familiar with the role of a credit applicant as both a borrower and a potential client for other lender products. Also, understand the concept of risk-based pricing and how it has changed the way that lenders price their products to different customers.

MODULE 23.1: CREDIT RISK

Retail Banking Risks

LO 23.a: Analyze the credit risks and other risks generated by retail banking.

The retail banking industry revolves around receiving deposits from and lending money to consumers and small businesses. Loans can take the form of home mortgages, home equity lines of credit (HELOCs), installment loans (revolving loans covering automobiles, credit cards, etc.), and small business loans (SBLs). From the perspective of the lending institution, these individual loans constitute small pieces of large portfolios designed to reduce the incremental risk to any one exposure.

The biggest risk associated with retail banking is **credit risk**, which is the likelihood that a borrower will default on debt. Throughout the five years preceding the 2007 subprime mortgage crisis, banks offered customers products they could not afford with risks that were more than customers could bear. **Loan-to-value (LTV) ratios** on mortgaged properties were very high and borrowers with weaker credit were given

mortgages. These strategies backfired when housing prices collapsed, which resulted in mortgages often exceeding the value of the properties themselves.

Although credit risk is the primary risk in retail banking, several other risks also impact the industry. These risks include:

- **Operational risks:** day-to-day risks associated with running the business.
- **Business risks:** strategic risks associated with new products or trends and volume risks associated with measures like mortgage volume when rates change.
- **Reputation risks:** the bank's reputation with customers and regulators.
- **Interest rate risks:** the bank provides specific interest rates to its assets and liabilities and rates change in the marketplace.
- **Asset valuation risk:** a form of market risk associated with the valuation of assets, liabilities, and collateral classes. An example includes prepayment risk associated with mortgages in decreasing rate environments. Valuation risk also exists in situations when car dealers assume a residual value for a vehicle at the end of the life of a lease.

Retail Credit Risk vs. Corporate Credit Risk

LO 23.b: Explain the differences between retail credit risk and corporate credit risk.

There are several features that distinguish retail credit risk from **corporate credit risk**. As mentioned earlier, retail credit exposures are relatively small as components of larger portfolios such that a default by any one customer will not present a serious threat to a lending institution. A commercial credit portfolio often consists of large exposures to corporations that can have a significant impact on their industry and the economy overall.

Due to the inherent diversification of a retail credit portfolio and its behavior in normal markets, estimating the default percentage allows a bank to effectively treat this loss as a cost of "doing business" and to factor it into the prices it charges its customers. A commercial credit portfolio is subjected to the risk that its losses may exceed the expected threshold, which could have a crippling effect on the bank.

Banks will often have time to take preemptive actions to reduce retail credit risk as a result of changes in customer behavior signaling a potential rise in defaults. These preemptive actions may include marketing to lower risk customers and increasing interest rates for higher risk customers. Commercial credit portfolios typically don't offer these signals, as problems might not become known until it is too late to correct them.

The Dark Side of Retail Credit Risk

LO 23.c: Discuss the "dark side" of retail credit risk and the measures that attempt to address the problem.

An unexpected, systematic risk factor may cause losses to rise beyond an estimated threshold, damaging a bank's retail portfolio through declines in asset and collateral values and increases in the default rate. This represents the "dark side" of retail credit risk.

Primary causes include:

- The lack of historical loss data due to the relative newness of specific products.
- An across the board increase in risk factors impacting the economy overall that causes retail credit products to behave unexpectedly.
- An evolving social and legal system which may inadvertently "encourage" defaults.
- An operational flaw in the credit process due to its semi-automated structure that results in credit granted to higher risk individuals.

The **Consumer Financial Protection Act (CFPA)**, in an attempt to manage the dark side of retail credit risk, requires credit originators to evaluate **qualified mortgages** and **ability to repay**.

A borrower with a "qualified mortgage" is assumed to have the capacity to repay. A qualified mortgage will put a limit on the amount of income allocated to debt repayments (e.g., debt-to-income ratio less than 45%). A qualified mortgage cannot have excess upfront fees and points, may not be balloon payment loans or interest-only loans, may not be for longer than 30 years, and may not be negative amortization loans.

When a lender is evaluating a customer's "ability to repay," the following underwriting standards must be considered:

- Credit history.
- Current income and assets.
- Current employment status.
- Mortgage monthly payments.
- Monthly payments on mortgage-related items such as insurance and property taxes.
- Monthly payments on other associated property loans.
- Additional debt obligations of the borrower.
- The monthly debt-to-income ratio resulting from the mortgage.

Due to the predictable and relative safety of retail credit, banks must set aside a relatively small amount of risk capital compared to requirements associated with corporate loans. Banks must provide regulators with specific statistics associated with differentiated segments of their portfolios. These statistics include: **probability of default (PD)**, **exposure at default (EAD)**, and **loss given default (LGD)**.

Credit Risk Scoring Models

LO 23.d: Define and describe credit risk scoring model types, key variables, and applications.

A **credit risk scoring model** takes information about an applicant and converts it into a number for the purpose of assessing risk; the higher the number, the higher the probability of repayment by the borrower and the lower the overall risk. Credit scoring models facilitate the gathering of an enormous amount of information into a single automated process.

A credit risk scorecard will gather information from applications and credit bureau reports and weight it depending on the type of questions answered. The question/entry will ask for a specific characteristic like "number of years with current employer," and the attribute will be the response (e.g., 10 years). Credit scoring models will determine positive and negative values and weight each attribute according to past history and the associated probability of repayment.

Three model types exist in regard to scoring applications for consumer credit:

- **Credit bureau scores:** this refers to an applicant's FICO score, and is very fast, easy, and cost effective to implement and evaluate. Scores will typically range from a low of 300 to a high of 850, with higher scores associated with lower risk to the lender and lower interest rates for the borrower.
- **Pooled model:** this model, built by outside parties, is more costly than implementing a credit bureau score model; however, it offers the advantage of flexibility to tailor it to a specific industry.
- **Custom model:** created by the lender itself using data specifically pulled from the lender's own credit application pool. This model type allows a lender to evaluate applicants for their own specific products.

Every individual with a credit history will have credit files containing the following information:

- Personal (identifying) information which doesn't factor into scoring models.
- Records of credit inquiries when a file is accessed. Requests for new credit will be visible to credit grantors.
- Data on collections, reported by entities that provide credit or agencies that collect outstanding debts.
- Legal (public) records on bankruptcies, tax liens, and judgments.
- Account and trade line information gathered from receivables information sent to credit bureaus by grantors.

MODULE QUIZ 23.1

1. Which of the following statements is most accurate regarding risks incurred by retail lenders?

   A. Reputation risk is more of a concern for the borrower rather than the lender.
   B. Business risk relates to the day-to-day operational risks of the business.

C. Credit risk relates to the potential for a lender to default on their obligation.
D. Refinancing a mortgage when rates decrease is an example of asset valuation risk.

2. The dark side of retail credit risk is perpetuated by all of the following factors except:
   A. capital set aside to protect a bank in the event of default.
   B. process flaws resulting in high risk applicants receiving credit.
   C. new products which do not have sufficient historical loss data.
   D. a social acceptance of bankruptcy and borrowers "walking away" from their obligations.

3. Which of the following statements is correct regarding credit risk scoring models?
   A. A pooled model will result in scores ranging from 300 to 850.
   B. A custom model is cheaper to implement than credit bureau scores.
   C. Multiple requests for new credit will reduce an applicant's credit score.
   D. An example of a characteristic in a scoring model is the applicant's current gross salary of $50,000.

MODULE 23.2: CREDITWORTHINESS

Mortgage Credit Assessment

LO 23.e: Discuss the key variables in a mortgage credit assessment and describe the use of cutoff scores, default rates, and loss rates in a credit scoring model.

In assessing an application for mortgage credit, the key variables include:

- **FICO score:** a numerical score serving as a measure of default risk tied to the borrower's credit history.
- **Loan-to-value (LTV) ratio:** the amount of the mortgage divided by the associated property's total appraised value.
- **Debt-to-income (DTI) ratio:** the ratio of monthly debt payments (mortgage, auto, etc.) to the monthly gross income of the borrower.
- **Payment (pmt) type:** dictates the type of mortgage (adjustable rate, fixed, etc.).
- **Documentation (doc) types**, which include:
  - *Full doc*: a loan which requires evidence of assets and income.
  - *Stated income*: employment is verified but borrower income is not.
  - *No ratio*: similar to stated income, employment is documented but income is not. The debt-to-income ratio is not calculated.
  - *No income/no asset*: income and assets are provided on the loan application but are not lender verified (other than the source of income).
  - *No doc*: no documentation of income or assets is provided.

Cutoff Scores

Cutoff scores represent thresholds where lenders determine whether they will or will not lend money (and the terms of the loan) to a particular borrower. As noted earlier, the higher the score, the lower the risk to the lending institution. Setting the cutoff

score too low presents a higher risk of default to the lender. Setting the cutoff score too high may limit potential profitable opportunities by unintentionally eliminating low risk borrowers.

Once the cutoff score is established, historical experience can be used to establish the estimated profitability for a specific product line and the associated loss rate. As estimates are made from longer time horizons (which hopefully capture a full economic cycle), a bank may adjust its cutoff score to maximize the appropriate balance between risk and profitability.

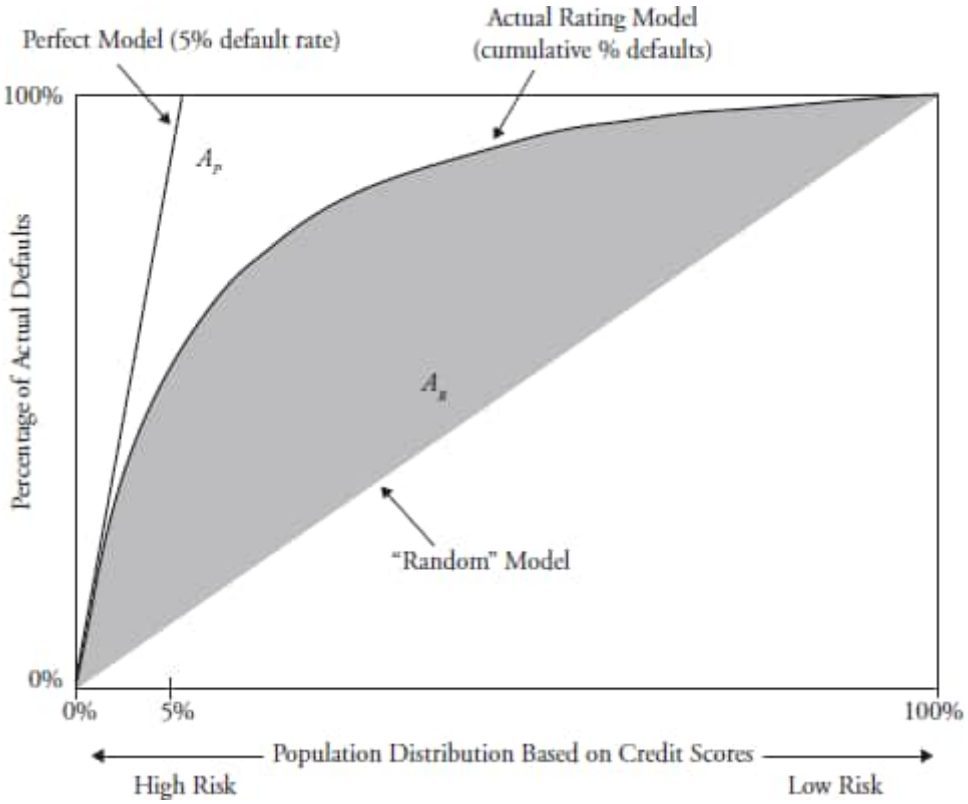
Banks are required by the Basel Accord to group their portfolios into subgroups that share similar loss attributes, with score bands used to differentiate the groups by risk levels. For each of these subgroups, banks are required to estimate the PD and the LGD. The implied PD is a by-product of the historical loss rate and the LGD such that if a portfolio has a loss rate of 3% with a 75% LGD, then the PD is 4% (i.e., 3% / 75% = 4%).

Scorecard Performance

LO 23.f: Discuss the measurement and monitoring of a scorecard performance including the use of cumulative accuracy profile (CAP) and the accuracy ratio (AR) techniques.

Credit scoring is used as a means of predicting default risk, such that high (low) scores on the scorecard are assigned to strong (weak) credits. In assessing the performance of the scorecard, a **cumulative accuracy profile (CAP)** and the **accuracy ratio (AR)** are often used. The CAP shows the population distribution based on credit scores (and therefore risk) versus the percentage of actual defaults.

Figure 23.1: Cumulative Accuracy Profile and Accuracy Ratio



Lines plotted on the graph include the perfect model line, random model line, and observed cumulative default percentage line defined as follows:

- In a perfect model, if the bank predicts, for example, 5% of its accounts will default over a specific period, 100% of those defaults will come from the riskiest 5% of the population.
- A random model will assume 5% of the defaults will come from the riskiest 5%, 20% will come from the riskiest 20%, etc.
- The observed cumulative default line represents the actual defaults observed by the bank.

The area between the perfect model and the random model is represented by A_P, while the area between the observed cumulative default percentage line and the random line is represented by A_R. The accuracy ratio (AR) is defined as A_R/A_P, with a ratio close to 1 implying a more accurate model.

A scoring model must be monitored on a regular basis due to underlying changes in the population as well as potential product changes.

Tradeoff Between Creditworthiness and Profitability

LO 23.g: Describe the customer relationship cycle and discuss the trade-off between creditworthiness and profitability.

Entities in the business of loaning money do not focus entirely on risk and creditworthiness; they also have to evaluate customers from the perspective of profitability. If a credit card is issued to a customer with a very high FICO score who pays their bill in full every month, the bank will not earn any interest from that customer on borrowed funds. At the same time, issuing that same credit card to a customer with a low FICO score is a greater risk because the customer may be unable to pay back loaned funds. Along with credit default scoring, lenders are using product and customer profit scoring measures to evaluate the potential profitability of a specific product and the potential profitability of a specific customer.

In utilizing scorecards to evaluate customers, there are several variations beyond just the credit bureau (FICO) scores. These additional scorecards can be used to evaluate both creditworthiness and profitability. They include:

- *Revenue scores*: used to evaluate existing customers on potential profitability.
- *Application scores*: used to support the decision to extend credit to a new applicant.
- *Response scores*: assign a probability to whether a customer is likely to respond to an offer.
- *Insurance scores*: assign a probability to potential claims by the insured.
- *Behavior scores*: assess existing customer credit usage and historical delinquencies.
- *Tax authority scores*: predict where potential audits may be needed for revenue collection.
- *Attrition scores*: assign a probability to the reduction or elimination of outstanding debt by existing customers.

The **customer relationship cycle** involves the process a lender goes through to market its products/services, screen applications from customers, manage customer accounts, and then cross-sell to those customers. Marketing efforts will focus on selling new or tailoring existing products to meet the needs of both new and existing customers. Applicant screening involves the acceptance or rejection of an application based on scorecards noted previously, as well as ultimately determining the appropriate price to charge for accepted applicants. Managing the customer account will primarily involve product pricing, credit line authorizations, modifications, renewals, and principal or interest collections. Cross-selling efforts will target existing customers by offering other lender products to meet their needs.

Risk-Based Pricing

LO 23.h: Discuss the benefits of risk-based pricing of financial services.

Recognizing that charging a single price for a product to all customers regardless of risk levels may lead to adverse selection (i.e., high-risk customers attracted to a relatively low price relative to their risk profile and low-risk customers pushed away by the higher price relative to their risk profile), lenders have been moving toward **risk-based pricing (RBP)**. RBP involves lenders charging different customers different prices based on their associated risks. Although RBP is still in the early stages of implementation in the financial retail sector, it has been utilized more frequently in credit card, home mortgage, and auto loan lines.

Key external and internal factors which account for risk and play into the interest rates and prices charged by lenders include:

- The probability of **take-up** (i.e., acceptance by the customer of the offered product).
- The probability of default (PD).
- The loss given default (LGD).
- The exposure at default (EAD).
- The cost of equity capital to the lender.
- Capital allocated to the transaction.
- Operating expenses of the lender.

Prices may be set on a tiered level based on score bands allocating risks from high to low. The lender can then map pricing strategies to metrics such as profit/loss, revenue, market share, and risk-adjusted return at the various score bands. Utilizing RBP effectively allows management to evaluate the inevitable tradeoffs among profitability, market share, and risk with the short and long-term goal of increasing shareholder value.

MODULE QUIZ 23.2

1. In assessing the key variables associated with a potential mortgage loan, a bank will charge a higher interest rate if the borrower has a relatively:
   A. high FICO score.
   B. high loan-to-value ratio.
   C. low debt-to-assets ratio.
   D. low debt-to-income ratio.

2. By implementing risk-based pricing on its mortgage products, a bank will likely charge a:
   A. higher interest rate to a customer with a higher FICO score.
   B. lower interest rate to a customer with a lower credit bureau score.
   C. higher interest rate to a customer with a higher probability of default.
   D. lower interest rate to a customer positioned on a lower relative score band.

KEY CONCEPTS

LO 23.a

Retail banking involves the acceptance of deposits and lending of money to customers. Credit risk (the probability that a borrower will default on debt obligations) represents the biggest risk in retail banking. Other risks include operational risks, business risks, reputation risks, interest-rate risks, and asset valuation risk.

LO 23.b

Retail credit risk differs from corporate credit risk in the following significant ways:

- Retail exposures are relatively small such that one default has minimal impact, whereas commercial exposures are much larger and single defaults can have a significant impact.
- Losses exceeding expected thresholds can have a much greater impact for corporate portfolios than retail portfolios.
- Lenders can take preemptive actions to reduce retail credit risks, whereas commercial portfolios often send warning signals after it is too late.

LO 23.c

The "dark side" of retail credit risk occurs when a large scale risk factor causes a decline in asset values coupled with an increase in default rates. The end result is losses which exceed an estimated threshold. Lenders offering mortgage loans must evaluate customers' ability to pay as well as determining whether a mortgage is "qualified." In addition, banks must segment their portfolios and set aside risk capital as well as assess exposures and probabilities of default along with potential losses.

LO 23.d

A credit risk scoring model assigns (to each credit applicant) a score which serves as a measure of borrower risk; the higher (lower) the score, the lower (higher) the risk that the borrower won't be able to pay the debt obligation. Models include credit bureau scores, pooled models, and custom models which all use applicant data and weight them based on their historical relationship to potential defaults.

LO 23.e

Key variables associated with mortgage credit applications include FICO scores, loan-to-value ratios, debt-to-income ratios, payment types, and documentation types. Cutoff scores are thresholds set by lenders which dictate whether credit will or will not be extended, as well as terms associated with the loans. Probability of default and loss given default metrics are critical to assessing the risk associated with various lender portfolios.

LO 23.f

The cumulative accuracy profile (CAP) and the accuracy ratio (AR) are used to assess the performance of a credit scorecard. The closer the accuracy ratio is to 1, the more accurate the CAP model is at predicting the distribution of defaults relative to the risk levels of the associated population.

LO 23.g

For new and existing credit applicants, lenders may use a variety of scorecards to evaluate both creditworthiness and potential profitability. The customer relationship cycle involves marketing products, screening applicants, managing customer accounts, and eventual cross-selling to an existing customer base.

LO 23.h

Risk-based pricing (RBP) involves charging different prices for the same product such that higher (lower) prices can be charged to higher (lower) risk customers. Several external and internal factors are used to determine the prices charged, which are then evaluated in conjunction with various key performance metrics at each score (risk) band in order to maximize the tradeoff between risk and profitability.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 23.1

1. **D** Refinancing a mortgage is considered a prepayment risk to the lender, which is a component of asset valuation risk. When rates decrease, borrowers are more likely to refinance their existing (higher rate) mortgage into a lower rate obligation. The lender then earns less in interest on the debt obligation than they would have previously. Reputation risk is primarily a concern for the lender. Business risk relates to strategic risks tied to new products and volume, while credit risk is the risk that the borrower (rather than the lender) will default. (LO 23.a)

2. **A** Capital must be set aside to protect banks in the event of default, but this is a response to the dark side of retail credit risk rather than a perpetuating factor. A process flaw which grants credit to high risk individuals, a new product which doesn't have historical loss data, and the social "acceptance" of failing to meet debt payments are all considered perpetuating factors of retail credit risk. (LO 23.c)

3. **C** An individual's credit file will show a history of credit requests, with multiple requests causing an applicant's credit score to decline. A credit bureau score model (rather than pooled model) will result in scores ranging from 300 to 850. A custom model is more expensive to implement than credit bureau scores. "Gross salary with current employer" is an example of a characteristic, with the actual salary number itself representing an attribute. (LO 23.d)

Module Quiz 23.2

1. **B** The loan-to-value ratio represents the amount of the mortgage versus the appraised value of the property. The higher this ratio is for a property and an associated borrower, the more risk there is to the lender. In order to protect their position, a lender will charge a higher interest rate. Each of the other scenarios will result in a lower interest rate. (LO 23.e)

2. **C** The more likely it is that a customer will default, the higher the interest rate the bank will charge. A customer with a higher (lower) FICO/credit bureau score will be offered a lower (higher) interest rate. A customer positioned on a lower relative score band will be offered a higher interest rate. (LO 23.h)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Damodaran.

READING 24

COUNTRY RISK: DETERMINANTS, MEASURES, AND IMPLICATIONS

Study Session 4

EXAM FOCUS

Sovereign risks vary across countries. Factors such as political risk, legal risk, position in the economic growth cycle, and economic diversity impact a country's risks as well as investor appetite for their bonds. Rating agencies rate sovereign risks, which is an important component of assessing a country's credit risk. In the last three decades, countries have relied less on bank debt in favor of issuing public bonds. This has given rise to analyzing country risk by using sovereign default spreads. For the exam, be able to compare and contrast the advantages of sovereign credit ratings and sovereign default spreads. Understand the issues that can impede the value of ratings, such as herd behavior, timeliness, and rating biases. Also, be able to identify sources of sovereign risk and describe the consequences that result from sovereign defaults, and be able to describe sovereign defaults across time. Finally, ensure that you understand and are able to contrast credit ratings, sovereign default spreads, and credit default swap (CDS) spreads.

MODULE 24.1: COUNTRY RISK

LO 24.a: Identify and explain the different sources of country risk.

Investors are increasingly exposed to **country risk**, both directly and indirectly. First, innovations in financial markets have made investing in nondomestic companies easier for investors. Individuals now have a range of investment options including mutual funds that invest in foreign markets, exchange-traded funds (ETFs), and shares of foreign stock that are traded on domestic exchanges (including American depositary receipts [ADRs] in the United States and global depositary receipts [GDRs] in European markets). Second, companies are increasingly global, and many firms rely on growth in foreign markets to drive profits and returns to shareholders. Risk exposures vary across countries, with government actions directly influencing country risk and therefore the attractiveness of an investment.

Key sources of country risk include: (1) where the country is in the economic growth life cycle, (2) political risks, (3) the legal systems of countries, including both the structure and the efficiency of legal systems, and (4) the disproportionate reliance of a country on one product/commodity or service.

Economic Growth Life Cycle

More mature markets and companies within those markets are less risky than those firms and countries in the early stages of growth. Young growth companies rely on a stable macro environment and often have limited resources to withstand setbacks relative to mature companies. Similarly, early growth and emerging market countries are more vulnerable and are thus exposed to higher levels of risk than mature countries. Early growth countries generally have higher growth rates in recoveries and larger declines in GDP growth in downturns than their more mature counterparts. Equity markets are impacted as well. For example, in 2008, U.S. and European equity markets dropped by 25% to 30% while emerging markets fell by 50% or more. This is evidence that there is greater risk in early growth global investing even in countries that have sound legal systems and are well governed.

Political Risk

Political risk is broad and includes everything from whether a country is a democracy or a dictatorship to the smoothness with which a country transfers political power (e.g., military coups vs. democratic elections). There are four main components of political risk:

1. **Continuous versus discontinuous risk.** While it may be surprising to those living in a democracy, some investors prefer the stability of investing in companies in countries with autocratic leadership (i.e., one leader controls decision-making). The notion is that government policies are locked in and predictable and changes can be made more easily compared to a democracy where an election can change government policies fairly significantly. One of the risks of an authoritarian state is that significant costs of corruption and lack of legal systems can outweigh the benefits.

   Risks in democracies are continuous but generally low. In contrast, risks in dictatorships are discontinuous. Policies change much less frequently, but changes are often severe and difficult to protect against (i.e., discontinuous risk). For example, wars can adversely impact investment in businesses, including the disappearance of most international investors in Russian businesses following Russia's invasion of Ukraine in 2022. Studies are mixed regarding which system, authoritarian or democratic, results in higher economic growth. A 2021 report by *The Economist* indicates that only 6.4% of the world's population lives in democracies, while nearly one-third lives in authoritarian countries.

2. **Corruption.** There are costs associated with government corruption. Corruption costs can be likened to an implicit tax, directly reducing company profits and returns and indirectly reducing investor returns. Because the "tax" is not explicit and may also result in legal sanctions against the firm operating in the corrupt system (e.g., if

a firm is caught bribing an official), it increases risk. Using survey data, Transparency International ranks countries based on the level of corruption that is present. According to its 2021 survey, Denmark, Finland, and New Zealand are recognized as the least corrupt countries, while South Sudan is perceived as the most corrupt, followed by Somalia and Syria.

3. **Physical violence.** There are economic costs (e.g., insurance and security costs) and physical costs (e.g., possible physical harm to employees or investors) associated with countries in conflict. The Institute for Economics and Peace publishes the annual Global Peace Index, which maps countries by their level of peace/violence.
4. **Nationalization and expropriation risk.** Firms that perform well may see their profits expropriated via arbitrary taxation by governments. A firm may be nationalized, in which case the owners will receive much less than the true value of the company. Risks are greater in countries where nationalization and/or expropriation are possible, especially impacting natural resource companies.

Legal Risk

The protection of property rights (i.e., the structure of the legal system) and the speed with which disputes are settled (i.e., the efficiency of the legal system) affect risk. If disputes cannot be settled in a timely fashion, it is in essence the same as a system that does not protect property rights at all. Overall, investor and business protection is key in determining legal risk. For example, the ability of insiders to issue new shares to themselves at below-market prices in a particular country could lead to investors paying less for shares given these risks.

Several nongovernment organizations have created an international property rights index. Australia and North America are ranked the highest, while Latin America and Africa are ranked the lowest in terms of protection of property rights.

Economic Structure

A disproportionate reliance on a single commodity or service in an economy increases a country's risk exposure. For example, the economies of some countries rely almost exclusively on oil production. Other countries have the bulk of their economic output tied to banking or insurance while still others depend on tourism. A downturn in the demand (and/or price) for the good or service on which the country is dependent can devastate the economy, increasing risks for businesses and investors. It is not only the affected industry but also all of the businesses in the country/region that can be affected by a downturn. Diversification in these countries, especially in smaller economies, can be difficult because maintaining a concentration in resources can create significant wealth for those who control these resources, and therefore they have no incentive to diversify away from the key resource.

The United National Conference on Trade and Development (UNCTAD) measures the degree of dependence on commodities in emerging markets. The study indicates that Africa and Latin America are especially dependent on commodity exports, resulting in economies that are highly sensitive to changes in commodity prices, which increases country risk.

PROFESSOR'S NOTE

This phenomenon can happen in regions, countries, and even neighborhoods. For example, when much of the trading was shut down in the futures pits in Chicago in July 2015, there were many reports that described the economic impact on the "region," restaurants, retailers, and barbershops, all facing imminent demise as a result of the death of the key economic engine in the neighborhood.

Evaluating Country Risk

LO 24.b: Evaluate the methods for measuring country risk and discuss the limitations of using those methods.

There are various risk services that evaluate country risk, including the following:

- **Political Risk Services (PRS).** This for-profit firm evaluates more than one hundred countries on the key areas of country risk. Political, economic, and financial risk dimensions are evaluated using 22 variables to measure risks. The firm provides a composite score as well as a score on each of the three dimensions. In its 2022 update, Lebanon was ranked lowest (i.e., the riskiest country) and Norway was ranked highest (i.e., the least risky country) in terms of aggregated country risks.
- ***Euromoney.*** This magazine surveys 400 economists who assess country risk factors and rank countries from 0 to 100 with higher numbers indicating lower risk.
- ***The Economist.*** Currency risk, sovereign debt risk, and banking risks are assessed by this magazine to develop country risk scores.
- **The World Bank.** The World Bank compiles risk measures from several sources on 215 countries. Risk measures assess six areas, including the level of corruption, government effectiveness, political stability, rule of law, voice and accountability, and regulatory quality. Positive numbers imply less risk and negative numbers imply more risk.

For investors and businesses to use country risk ratings, they must be meaningful to their specific concerns. There are many limitations associated with these risk services that may diminish their value to businesses and investors, including the following:

1. The methodologies used to generate scores are often developed by nonbusinesses and may have more relevance to economists and policymakers than to businesses and investors.
2. There is no standardization across the information providers. The World Bank's ratings are scaled around zero. Higher scores indicate lower risk in the *Euromoney* and PRS rankings while lower scores indicate lower risk in *The Economist*'s rankings. This makes it difficult to compare country risk assessments across providers.
3. The scores are better used as rankings than as true scores. For example, a country with a ranking of 70 in *The Economist* rankings can be interpreted as riskier than a country with a ranking of 35. However, one cannot conclude, using the rankings, that a country with a score of 70 is twice as risky as a country with a score of 35.

MODULE QUIZ 24.1

1. A portfolio manager for a hospital foundation is considering the inclusion of sovereign bonds in the fixed income portion of the foundation's portfolio. Much to the surprise of his colleagues, the manager plans to purchase the bonds of a country that has long been under authoritarian rule. He cites "lower political risk" when asked about his investment decision. Which of the following statements is most likely what the manager meant by his assertion of lower risk?
   A. Authoritarian regimes are more likely to control corruption in government agencies.
   B. Government policies that may affect debt repayment are often more stable under an authoritarian regime.
   C. Relative to a democracy, risks are greater on a day-to-day basis, but the effects are less detrimental overall.
   D. In most authoritarian countries, property rights are protected and property disputes are settled quickly.

2. In an attempt to understand country risk, an analyst at Global Funds examines multiple sources of information to determine the truest measure of risk. She considers sovereign risk ratings, default risk spreads, and composite measures of risk. Which of the following sources relies on surveys of several hundred economists to measure sovereign risk?
   A. Political Risk Services.
   B. *The Economist*.
   C. The World Bank.
   D. *Euromoney*.

MODULE 24.2: SOVEREIGN DEFAULT RISK

LO 24.c: Compare and contrast foreign currency defaults and local currency defaults.

Sovereign default risk refers to the risk that holders of government-issued debt fail to receive the full amount of promised interest and principal payments during the specified time period. Sovereign default risk can be used as a proxy for country risk. Sovereign default categories include foreign currency defaults and local currency defaults.

Foreign Currency Defaults

Throughout history, some governments have relied on debt borrowed from other countries or banks in those countries. The debt, denominated in the foreign currency, is called **foreign currency debt**. Countries default on foreign currency debt from time to time because they are without the foreign currency to meet the obligation and are unable to print money in a foreign currency to repay the debt. A large proportion of sovereign defaults are foreign currency defaults. Between 1983 and 2021 there have been more than 30 foreign currency defaults. Overall, the largest sovereign default during the period was Greece, which defaulted on more than $264 billion in 2012.

According to a 2007 study, defaults over the previous 200 years occurred primarily during seven distinct time periods: 1824–1834, 1867–1882, 1890–1900, 1911–1921,

1931–1940, 1976–1989, and 1998–2003. In Europe, the greatest number of defaults occurred from 1931 to 1940. The same period also saw a number of foreign currency defaults in Latin America. The early 1980s was another key period for Latin American defaults with 16 countries defaulting, 15 of which occurred between 1980 and 1983. There have also been defaults in Asia and Africa over the last 50 years.

The following general conclusions can be drawn based on previous studies on sovereign defaults:

1. Countries were more likely to default on funds borrowed from banks than on sovereign bond issues.
2. Latin America accounts for a large proportion of sovereign defaults in the last 50 years (measured in dollar value terms).

Except for the 1990s, in each of the last five decades, Latin America has accounted for at least 60% of the foreign currency defaults. In fact, Latin America has been at the center of sovereign defaults for the last 200 years. To put it in historical perspective, in the 19th century, Latin America attracted capital from France, Britain, and Spain because of abundant natural resources. Latin American countries did not have significant domestic savings and thus borrowed heavily in gold and in foreign currency during this period. Maturities were long, usually greater than 20 years. Military coups and conflicts were the primary triggers of default on this debt. Between 1820 and 1919, 58 of the 77 sovereign defaults worldwide occurred in Latin America. Between 1825 and 1940, Uruguay spent 12% of the time in default (the shortest period) while Honduras spent 79% of the time in default, and Latin American countries collectively spent 38% of the time in default.

Local Currency Defaults

Many of the countries that defaulted on foreign currency debt over the last several decades were simultaneously defaulting on **local (i.e., domestic) country debt**. An S&P study of local currency defaults since 1975 indicates that 23 issuers have defaulted. Defaulting countries range from Russia in 1998–1999 to Argentina in 2002–2004. The largest local currency default in dollar terms occurred in 1990 when Brazil defaulted on $62 billion of debt. Russia defaulted on $39 billion of ruble debt in 1998–1999.

A study by Moody's finds that countries are increasingly defaulting on both foreign and local currency debts concurrently as shown in Figure 24.1.

Figure 24.1: Changes in Concurrent Default in Foreign and Local Currency Debt

Default Type	1960–1996	1997–2007
Foreign currency only	57%	29%
Local currency only	38%	29%
Both foreign and local	5%	42%

From Figure 24.1, you can see that the instance of concurrent defaults (i.e., local currency and foreign currency simultaneous defaults) has increased from 5% in the 1960 to 1996 period to 42% in the 1997 to 2007 period. Foreign currency only and local currency only defaults fell during the same period.

In a 2021 study, the Bank of Canada assessed sovereign defaults by types of creditors between 1976 and 2020. The study found that defaulted debt shifted toward local currency debt and nonbank borrowings, from foreign currency debt and bank loans. A separate 2022 study found that countries have moved more toward defaults on local currency debt under domestic law, given the greater efficiency and faster time of restructurings compared to foreign currency debt defaults.

It is difficult to explain why countries default on local currency debt. It would seem that countries would simply print more money to meet their obligations. However, there are three reasons that help explain local currency defaults:

1. **Gold standard.** Before 1971, some countries followed the gold standard. This means the country was required to have gold reserves to back its currency. The gold standard thus limited the amount of currency a country could print, reducing its flexibility in terms of printing currency to repay debt.
2. **Shared currency.** The euro is an example of a shared currency. The advantage of a shared currency is convenience for businesses, tourists, and so on. It eliminates the costs of converting currencies and increases transparency. However, a shared currency limits the abilities of individual countries to print money. For example, during the 2015 Greek debt crisis, as a member of the European Union (EU), Greece was not able to print currency to pay off its debt.
3. **The tradeoff.** There are costs associated with printing money. Printing money may devalue and debase the currency. It also leads to higher inflation, sometimes exponentially higher inflation. There are costs associated with default and costs associated with printing money leading to currency devaluation. Countries have to decide which of these tradeoffs is the less costly option for them. A key factor in these decisions is whether and/or to what extent foreign currency debt is funding local currency assets. The greater the extent, the more negative the consequences of choosing to print more local currency because it increases inflation and devalues local currency, reducing asset values while leaving liabilities unchanged.

Consequences of Sovereign Default

LO 24.d: Explain the consequences of a country's default.

Historically, defaults were often followed by military actions. For example, when Egypt defaulted in the 1880s, Britain used military force to take over the government, as did Britain and France around the same time when Turkey defaulted. In the 20th century, countries that defaulted suffered a loss of reputation, making it more difficult and more expensive to borrow in the future. Countries also experienced turmoil in stock and bond markets, faced a decrease in real output, and had to deal with political instability as a result of default.

Default typically does mean a complete nonpayment or elimination of debt. Defaults usually involve complex negotiations leading to some form of exchange or restructuring of debt. An examination of research on sovereign defaults leads to the following conclusions:

- **GDP decline.** Gross domestic product (GDP) typically declines between 0.5% and 2.0% following a sovereign default. However, the decline is short-lived, usually within the first year following the default.
- **Lower sovereign ratings and borrowing costs.** One study finds that ratings of countries that have defaulted at least once since 1970 are one to two notches lower than the ratings of similar countries that have not defaulted. Also, borrowing costs are 0.5%–1.0% higher. The effects lessen over time.
- **Trade retaliation.** Sovereign default can cause trade retaliation. Export businesses are most affected. One study finds an average 8% drop in bilateral trade following a default. The study also finds the effects can last up to 15 years.
- **More fragile banking systems.** A study of 149 countries between 1975 and 2000 finds that there is a 14% probability of a banking crisis following a sovereign default, which is 11% higher than for nondefaulting countries.
- **Increased likelihood of political change.** Sharp currency devaluations often follow defaults. Countries that default on debt are more likely to see a change in the president or prime minister (a 45% increase in the probability of a change) and the finance minister or head of the central bank (a 64% increase in the probability of a change).

Factors Influencing Sovereign Default Risk

LO 24.e: Discuss measures of sovereign default risk and describe components of a sovereign rating.

Individuals, companies, and governments default for many of the same reasons. Primarily, they each borrow more than they can afford in good times and find themselves unable to repay the borrowed funds during downturns. Several factors influence a country's sovereign default risk. They are as follows:

1. **The country's level of indebtedness.** The level of indebtedness is the most fundamental factor used to determine the risk of default. One must consider not only the country's debts to foreign banks and investors, but also the amount the country owes its own citizens (e.g., for social safety nets such as welfare and universal health care). For comparison purposes, debt is typically scaled to a country's GDP. Some of the most indebted countries when looking at sovereign debt as a percent of GDP include the U.S., Japan, and France, which are considered highly creditworthy by financial markets and credit rating agencies. Debt levels in the U.S. have increased since 2008 and have further increased due to the COVID-19 pandemic. But this means that the level of indebtedness is not the only factor determining the risk of default. Other countries, such as Egypt and El Salvador, have high default risk as well.

Figure 24.2: Government Debt as a Percentage of GDP (as of 2020)

Country	Government Debt as a Percentage of GDP	
	2020	2010
Venezuela	304.12%	25.00%
Japan	254.13%	205.69%
Greece	211.21%	147.49%
Italy	155.82%	119.20%
Portugal	135.19%	100.21%
United States	133.92%	95.14%
Spain	119.92%	60.52%
Cyprus	119.14%	56.43%

Source: IMF Datasets, https://www.imf.org/external/datamapper/GG_DEBT_GDP@GDD/SWE

2. **Pension funds and social services.** Countries with greater pension commitments and health care commitments have higher default risk. (As these commitments increase as the population ages, countries with older populations face greater risks.)
3. **Tax receipts.** The greater the tax receipts, the more able a country is to make debt payments. A larger tax base should increase a country's revenues (i.e., tax receipts) and therefore lower default risk.
4. **Stability of tax receipts.** Governments must pay debt obligations in both good and bad economic times. This means the revenue stream must be stable to meet these fixed obligations. Countries with more diversified economies are more likely to have stable tax receipts. Countries like Jamaica, which depends on tourism, and Peru, which depends on silver and copper production, have more sovereign default risk than the governments of larger, more diversified economies such as India. Also, sales and value added tax systems are generally more stable than income tax systems.
5. **Political risk.** Autocracies may be more likely to default than democracies because defaults put pressure on, and may cause a change in, the leadership of the country. There may be less pressure on the leaders of dictatorships if the country defaults. Also, the more independent the central bank, the more difficult it may be for a country to print money.
6. **Backing from other countries/entities.** Rating agencies and other market participants reassessed and decreased the estimated default risk of Spain, Greece, and Portugal when those countries joined the EU. It is assumed that stronger economies like Germany, France, and the Nordic countries would protect weaker economies against default. However, there is no guarantee, and this is an implicit, not an explicit, backing.

Sovereign default risk is multifaceted and must be analyzed from many perspectives. The country's level of indebtedness, obligations to its citizens for things like pensions and medical care, and its tax systems are all relevant to assessing the risk of default. In addition, the trustworthiness of the government and the nature of the economy must also be considered when evaluating sovereign default risk.

Rating Agencies and Default Risk

Rating agencies have distinct advantages when it comes to assessing sovereign default risk. First, they have been assessing the default risk of corporations for more than a century, with these skills easily transferable to sovereign risk evaluation. Additionally, investors are accustomed to the ratings used for companies, so understanding the credit ratings of sovereign nations is intuitive.

By 1929, Moody's, one of the big three credit rating agencies, rated nearly 50 governments. Interest in government bonds waned following the Great Depression and World War II, however, it picked up slowly in the 1970s and has continued to grow. By 1994, there were 49 rated countries, rated from AAA/Aaa to BBB–/Baa3.

The market for sovereign bonds has since increased dramatically. In 2022, Moody's, S&P, and Fitch each rated more than 100 countries. Moody's and S&P currently provide two ratings for each country, a local currency rating for domestic currency bonds and a foreign currency rating for borrowings in a foreign currency. Figure 24.3 provides some examples of Moody's sovereign bond ratings.

Figure 24.3: Sample of Moody's Latin American Sovereign Ratings

Country	Foreign Currency Rating	Foreign Currency Outlook	Local Currency Rating	Local Currency Outlook
Argentina	Ca	STA (Stable)	Ca	STA (Stable)
Brazil	Ba2	STA (Stable)	Ba2	STA (Stable)
Chile	A1	NEG (Negative)	A1	NEG (Negative)
Mexico	Baa1	NEG (Negative)	Baa1	NEG (Negative)
Venezuela	C	STA (Stable)	C	STA (Stable)

Source: Moody's (July 2022)

The outlook column indicates the outlook on the ratings. For Moody's ratings, NEG indicates that there is a possibility of a downgrade, STA indicates a stable rating, and POS indicates the possibility of a ratings upgrade.

Generally, the local currency rating is at least as high as the foreign currency rating, because countries can print money in local currency to repay debt. There are some exceptions where the local currency rating is lower, as was the case of India in March 2010, which was assigned a local currency rating of Ba2 and a foreign currency rating of Baa3. Sovereign ratings are often similar across rating agencies but may diverge given their different views on idiosyncratic and macroeconomic risks, including their assessment of political risk.

Sovereign ratings could change over time, but usually change less frequently than corporate bond ratings. Rating changes are typically analyzed using rating transition tables, which indicate the rating changes of sovereigns over one-year periods. For example, using S&P's one-year rating transition data between 1975 and 2021, the calculated probability of a AAA-rated sovereign remaining AAA was 96.82%. A BBB-rated sovereign had a 90.25% probability of remaining unchanged, a 4.48% chance of being upgraded, and a 5.26% chance of being downgraded. When using 15-year

transition data, ratings change more frequently, with only 67.14% of AAA-rated and 25.25% of BBB-rated sovereigns holding their rating. A criticism of rating agencies is regional bias, meaning that agencies tend to underrate sovereigns in entire regions, for example in Latin America.

How Rating Agencies Measure Risk

The three main rating agencies use similar processes to determine sovereign ratings. The ratings process includes the following:

- **Ratings measure.** The goal is to determine the creditworthiness of a country. The agencies focus on the default risk faced by banks and private bondholders, not official creditors such as the World Bank and the International Monetary Fund (IMF). What is being measured also differs: S&P's ratings measure the probability of default while Moody's ratings measure both the probability of default and the severity of the default (i.e., the rating looks at the expected recovery rate in the event of default). Default is defined as the failure to pay principal or interest payments on the due date (i.e., outright default) or rescheduling or restructuring the debt (i.e., restructuring default).
- **Evaluating factors that may contribute to default.** These factors are related to the economic, political, and institutional detail of the country with respect to its ability to repay debt. Regarding the sovereign ratings methodology profile, S&P uses variables classified based on political risk, economic structure, economic growth prospects, fiscal flexibility, general government debt burden, offshore and contingent liabilities, monetary flexibility, external liquidity, and the country's external debt burden. Fitch and Moody's use similar frameworks for analyzing the risk of default.
- **Ratings process.** An analyst prepares a draft report, recommending the rating. A committee, typically composed of 5 to 10 people, debates the rating categories (i.e., political risk, economic structure, and so on) and other relevant information presented, and then votes on the final rating following closing arguments.
- **Local vs. foreign currency ratings.** Sovereign ratings typically include both a local currency rating and a foreign currency rating. The difference between the two is largely based on the country's monetary policy independence. Countries that have given up monetary policy independence (e.g., EU countries) will see their foreign and local currency ratings converge. Countries with floating rate exchange regimes that fund borrowing through sound domestic markets will have the greatest difference between the two ratings. Agencies use two general approaches to arrive at the foreign versus local currency ratings:
  - *Notch-up approach*. The foreign currency rating is the key indicator of sovereign default risk, and the local currency rating is "notched up" based on the domestic debt market and other domestic factors.
  - *Notch-down approach*. The local currency rating is the key indicator of sovereign default risk, and the foreign currency rating is "notched down" based on foreign exchange issues and constraints.
- **Ratings review process.** Ratings are reviewed on a periodic basis. In addition, news can trigger a ratings review. For example, an economic disaster in one country may

trigger a review not only of that country, but also of neighboring countries that may be subject to a contagion effect.

Sovereign Ratings vs. Default Risk

Rating agencies argue that despite some errors, there is a high correlation between sovereign ratings and sovereign default. S&P's cumulative default rate study from 1975 to 2021 supports this premise. For example, AAA-rated countries have not defaulted within a 15-month period following the rating assignment, while BBB-rated countries had a 4.78% probability of default over the same period, and CCC-rated countries had an 84.80% probability of default.

Shortcomings of the Sovereign Rating System

LO 24.f: Describe the shortcomings of the sovereign rating systems of rating agencies.

Rating agencies have been criticized on a number of counts. These include the following:

- **Ratings are biased upward.** Rating agencies are often viewed as too optimistic when it comes to rating sovereigns and corporations. The conflict of interest that is often cited as a problem in corporate ratings (i.e., the company pays the rating agency for the rating) is much less of a problem with sovereign ratings because any revenue received is small, while the reputational damage of overrating sovereigns is very high.
- **Herd behavior.** When one agency upgrades or downgrades a country, the other agencies tend to follow suit. This perceived lack of independence reduces the benefit of having three rating agencies.
- **Rating changes are not timely enough.** Investors need rating agencies to update ratings in a timely fashion. Some market participants feel that the agencies take too long to change ratings, leaving investors unprotected in the event of a crisis.
- **Overreaction leads to a vicious cycle.** Rating agencies have been criticized for overreacting to crises, lowering ratings too much in response to a crisis, which then worsens the crisis.
- **Ratings failures.** One study examined multiple ratings changes in a short period of time by S&P and Moody's. It can be argued that multiple rating changes within a single year imply that agencies were incorrect in their initial assessments of the country. The study offered several possible explanations for the ratings failures:
  - *Bad information*. Agencies rely on information from governments. There is significant variability in the amount and quality of the data that agencies receive across countries. If governments hide the truth and reveal only positive information, ratings will be incorrect. This may also help explain the upward bias discussed previously.
  - *Limited resources*. Rating sovereigns generate limited revenues for agencies. Analysts can be spread thin and often rate multiple countries. This may lead

analysts to rely on common information available in the market rather than doing their own research and may also contribute to herd behavior.

- *Revenue bias*. Rating agencies generally do not charge users for sovereign ratings. This means revenues must come either from the issuers or from other businesses. Rating agencies generate significant revenues from subsovereigns (e.g., states, provinces, counties, and cities). If some agency revenues arise from sovereigns or subsovereigns, a criticism is that there could be an incentive for the agency to refrain from issuing harsh judgments against a country. A sovereign ratings downgrade is usually followed by a series of subsovereign downgrades, and subsovereigns could fight the sovereign downgrade, contributing to the upward bias of sovereign ratings.
- *Other conflicts of interest*. There are off-shoot businesses from the core sovereign ratings business. These businesses may generate enough revenue to influence ratings. Typically, rating agency employees do not go work for the sovereigns they rate, thus, this issue does not generally pose a conflict of interest.

PROFESSOR'S NOTE

While some of the criticisms against rating agencies are valid, agencies have put in place significant guardrails against bias over the last several decades. The most significant of these guardrails is the separation—both physical and conceptual—between the commercial side of the ratings business (the relationship managers discussing products and fees with clients) and the analytical side (the rating analysts and supporting teams, which are prohibited from discussing commercial products with clients). This is meant to ensure the independence of the ratings and minimize any bias.

Credit Ratings, Default Spreads, and CDS Spreads

LO 24.g: Compare the use of credit ratings, market-based credit default spreads, and CDS spreads in predicting default.

Credit Ratings and the Sovereign Default Spread

There has been significant growth in the sovereign bond market, beginning in the 1980s. More countries have been avoiding bank debt in favor of issuing bonds. A key measure of sovereign default risk when comparing different sovereign bonds is the **sovereign default spread**. The sovereign default spread is the difference between the yield of a riskier sovereign bond yield and a riskless sovereign bond yield (e.g., U.S. Treasury bond yield). For example, the yield on a 10-year dollar-denominated Brazilian bond was 6.00% on July 1, 2022, while the yield on the 10-year U.S. Treasury bond was 3.02%. Because the U.S. Treasury bond is assumed to be risk free, the 2.98% difference between the two bond yields is the sovereign default spread and it reflects the market's assessment of the default risk of the Brazilian bond.

Figure 24.4 shows the comparison of default spreads and Moody's credit ratings for a sample of dollar-denominated bonds in July 2022.

Figure 24.4: Default Spreads on Dollar-Denominated Latin American Bonds

Country	Yield on Dollar-Denominated 10-Year Sovereign Bond	Yield on 10-Year U.S. Treasury Bond	Sovereign Default Spread	Moody's Sovereign Bond Rating
Brazil	6.19%	3.02%	3.17%	Ba2
Colombia	5.58%	3.02%	2.56%	Baa2
Indonesia	4.38%	3.02%	1.36%	Baa2
Turkey	10.92%	3.02%	7.90%	B2

Source: Bloomberg

Interestingly, Moody's sovereign ratings of both Columbia and Indonesia are the same (Baa2); however, the market demands a higher rate of return for the Colombian bonds (higher risk). In July 2022, the difference in default spreads between the two countries was 120 basis points (i.e., 2.56% – 1.36%).

The key advantages of the sovereign default spread are as follows:

1. **Market-based spreads are more dynamic than ratings.** As bonds trade and bond yields rise and fall, default spreads change, revealing information about the market's perception of risk. For example, in late 2005 the default spreads of Brazil and Venezuela were close, 3.18% and 3.09%, respectively. Spreads started to diverge between 2006 and 2009. By December 2010, the default spread had widened to 10.26% on the Venezuelan bonds and narrowed to 1.32% on the Brazilian bonds. It is clear that the market's perception of the relative risk of the two countries was changing, as evidenced by the diverging spreads.
2. **Spreads adjust quicker to new information.** Similar to the advantage that changes occur in real time, yield spreads adjust more quickly to new information regarding the sovereign relative to bond ratings. This means investors receive an earlier signal of potential threats and they can therefore adjust portfolios more quickly.

The key disadvantages of the sovereign default spread are as follows:

1. **Comparing local currency bond yields is less meaningful.** Local currency bonds do not have a risk-free security with which to compare. It is not practical to compare local currency bonds because differences in yields may reflect differences in expected inflation across countries rather than true risk. Also, even with dollar-denominated bonds, it is the assumption that U.S. Treasury bonds are default risk free that makes calculating a yield spread meaningful.
2. **Greater volatility in default spreads.** Default spreads are volatile and changes in spreads may be affected by variables that are unrelated to the default risk of the sovereign. For example, investor demand for the bonds and changes in liquidity can affect spreads but often have nothing to do with default risk.

Studies that have examined default spreads and ratings generally conclude the following:

- *Default spreads are positively correlated with ratings and with default.* In other words, low rated sovereign bonds are more likely to trade at higher yields (and yield spreads) and are more likely to default.
- *Default spreads are "leading indicators."* The spreads widen before a rating downgrade and narrow before a rating upgrade.
- *A rating change provides information to the market, despite the longer lag time relative to default spreads.* Rating agencies use market information to make decisions about rating changes. The market reacts to ratings and rating changes when pricing bonds. This means that both ratings and default spreads are useful to market participants when evaluating and understanding sovereign default risk.

CDS Spreads

Credit default swaps (CDSs) have gained significant prominence over the last decade, growing to nearly $60 trillion by the end of 2007 before declining in value after the great financial crisis. The overall number of players in this space is small, which exposes the CDS market to potential volatility if a few large entities fail. Although the sovereign CDS market remains a small portion of the overall market, its popularity has grown in recent years. By July 2022, there were CDS trading on 85 sovereigns.

A CDS is similar to buying insurance against a bond default. One party (the CDS buyer) pays periodic payments as a percentage of the bond notional value in each period to another party (the CDS seller). The CDS seller provides protection that in a predefined credit event, which could include a bond default or a restructuring, the seller makes the buyer "whole" against a loss on the bond. Settlement can be cash-based where the seller pays the difference between the bond's notional value and its market price, or physical where the buyer delivers the bond to the seller and receives the notional value in return.

For example, an investor may own $20 million notional value five-year Peruvian government bonds. If the investor is worried about a potential credit event over the next five years, it could buy a five-year CDS and pay 170 basis points (1.70%), or $340,000, annually to a CDS seller. The percentage (i.e., number of basis points) of notional value is known as the **CDS spread**. If a credit event such as a default or restructuring occurs over the next five years, the CDS buyer will either deliver the bond to the seller and receive $20 million, or receive from the seller the difference between the notional value and market value of the bond.

Note that there are two key risks in buying CDS protection. First, a credit event must occur in order for the protection buyer to receive a payment. If the bond value declines due to other reasons, no credit event occurred and the CDS buyer would not receive a payment. Second, the buyer is exposed to the credit risk that the seller may not be willing or able to make a payment even if a credit event occurs.

CDS spreads adjust more quickly to market information than ratings do, making them valuable to investors and institutional players. This difference in the speed of adjustment to new risks was especially evident during the 2009–2010 period, when CDS spreads of several European sovereigns including Greece changed much more

frequently than the sovereign ratings. Analyzing the change in CDS spreads leads to several important conclusions:

1. Changes in CDS spreads influence sovereign bond yields and ratings.
2. CDS spreads are better predictors of sovereign risk than credit ratings.
3. Increased macroeconomic risks result in increases in CDS spreads, which are also often accompanied by currency depreciations.
4. Contagion (or clustering) leads CDS spreads of groups of countries to move together.

There are two key limitations to relying on CDS spreads. First, CDS spreads reflect a range of risks including credit, market, and liquidity risks. As a result, using CDS spreads to assess only credit risk could overestimate the risks. Second, CDSs are often illiquid, which distorts their prices. Despite these limitations, CDSs contain significant information about default risk, although they have not been proven to be more beneficial in assessing default risk than market-based default spreads.

MODULE QUIZ 24.2

1. Which of the following statements regarding foreign currency defaults is true?
   A. African countries are responsible for the greatest number of defaults in the last 50 years.
   B. Before the 20th century, no country had ever defaulted on funds borrowed in a foreign currency.
   C. Latin America accounted for more than 60% of foreign currency defaults in the 1990s.
   D. Countries are more likely to default on funds borrowed from foreign banks than on sovereign bond issues.

2. Following a sovereign default:
   A. borrowing costs rise 1.0% to 2.5%, and the country is more likely to suffer a banking crisis.
   B. countries are more likely to suffer banking crises and GDP growth generally falls 2.0% to 3.5%, but the drop is usually short-lived.
   C. ratings fall one to two notches, and GDP growth falls between 0.5% to 2.0%.
   D. trade retaliations are likely to occur but are short-lived, lasting only six months to one year.

KEY CONCEPTS

LO 24.a

Key sources of country risk include where the country is in the economic growth life cycle, political risks, the legal systems of countries, including both the structure and the efficiency of legal systems, and the disproportionate reliance of a country on one commodity or service.

Regarding economic life cycle, more mature markets and companies within those markets are less risky than those firms and countries in the early stages of growth.

Regarding political risk, there are at least four components of political risk, including the level of corruption in the country, the occurrences of physical violence due to wars

or civil unrest, the possibility of nationalization and expropriations, and the continuity and severity of risks versus discontinuous risks.

Regarding legal risks, the protection of property rights and the speed with which disputes are settled affect default risk.

Regarding economic structure, a disproportionate reliance on a single commodity or service in an economy increases a country's risk exposure.

LO 24.b

Entities including Political Risk Services (PRS), *The Economist*, *Euromoney*, and the World Bank evaluate countries on key areas of country risk. Some are critical of these composite risk measures because they are not readily comparable with each other due to a lack of standardization across the information providers. Also, the methodologies used to generate scores are often developed by nonbusiness entities and may have more relevance to economists and policymakers than to businesses and investors. Finally, the scores are better used as rankings than as a way to interpret the relative risk of countries.

LO 24.c

There are many causes of sovereign defaults. It is easier to understand foreign currency defaults than local currency defaults. Countries are often without the foreign currency to meet the debt obligation and are unable to print money to repay the debt. This makes up a large proportion of sovereign defaults.

Many of the countries that defaulted on foreign currency debt over the last several decades were simultaneously defaulting on local country debt. Three reasons may explain local currency defaults: (1) the use of the gold standard before 1971 made it more difficult for some countries to print money, (2) shared currencies, such as the euro, make it impossible for countries to control their own monetary policy, and (3) some counties may conclude based on a tradeoff theory that the costs of currency debasement and potentially higher inflation are greater than the costs of default.

LO 24.d

Historically, defaults were often followed by military actions. Research suggests the following additional consequences of sovereign defaults:

- GDP growth falls following a sovereign default (between 0.5% and 2.0%).
- Borrowing costs are higher following default (by 0.5% to 1.0%).
- Sovereign default can cause trade retaliation (bilateral trade can drop by 8%).
- Sovereign defaults are often followed by banking crises (14% probability of a banking crisis following a sovereign default).
- Sovereign defaults often lead to political change in top leadership and top finance positions.

LO 24.e

Several factors determine a country's sovereign default risk. The country's level of indebtedness, obligations such as pension commitments and social service commitments, the country's level of and stability of tax receipts, political risks, and backing from other countries or entities all impact a country's likelihood of defaulting on sovereign debt.

Rating agencies consider several factors when evaluating default risk. These factors are related to the economic, political, and institutional characteristics of a country with respect to its ability to repay debt. The ratings process includes an analyst preparing a draft report and recommending a rating. A committee votes on the recommendation including the final rating. Ratings are reviewed periodically and may also be reviewed following a significant market event that impacts the likelihood of default.

LO 24.f

Rating agencies have been criticized on numerous counts, including:

- ratings are often viewed as upward biased;
- the ratings established by major rating agencies (i.e., S&P, Moody's, and Fitch) tend to mirror each other;
- sovereign rating changes are slow to change;
- rating agencies could overreact to news impacting a sovereign; and
- ratings are simply incorrect in some cases.

LO 24.g

Advantages of sovereign default spreads relative to sovereign bond ratings are that changes occur in real time, risk premiums adjust to new information more quickly, and there is more granularity in default spreads than in risk ratings.

Disadvantages of sovereign default spreads include more volatility, spreads include more information than just default risk (e.g., changes in liquidity and investor demand), and local currency bonds cannot be compared with each other because differences may reflect differences in expected inflation rather than differences in default risk.

Credit default swaps (CDSs) have gained prominence over the last decade. A CDS is similar to buying insurance against a bond default. Key risks in buying CDS protection include the need for a specified credit event to occur in order for a payout to happen, and the exposure by the CDS buyer to the credit risk of the seller.

Relying on CDS spreads is useful because they adjust more quickly to market information than ratings. Changes in CDS spreads influence sovereign bond yields and ratings. Increases in CDS spreads are also often accompanied by currency depreciations. However, CDS spreads of a group of countries may cluster (i.e., change together). The usefulness of CDSs is limited because their spreads reflect not only credit

risk but also liquidity risk and investor demand. CDSs are also often illiquid, which distorts their prices.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 24.1

1. **B** Some investors prefer the stability of investing in countries with autocratic governments because government policies are locked in and generally more predictable compared to democratic countries where an election can significantly change government policies. Risks in a democracy are continuous, but usually low. In contrast, risks in a dictatorship are discontinuous. Policies change much less frequently, but changes are often severe and difficult to protect against. The portfolio manager is willing to accept the bigger, discontinuous risk as a tradeoff for the more frequent, but less damaging, continuous risk. (LO 24.a)

2. **D** Numerous services attempt to evaluate country risk in its entirety. They include Political Risk Services (PRS), *The Economist*, *Euromoney*, and the World Bank. *Euromoney* surveys 400 economists who assess country risk factors and rank countries from 0 to 100, with higher numbers indicating lower risk. (LO 24.b)

Module Quiz 24.2

1. **D** Historically, countries have been more likely to default on foreign bank debt than on sovereign bonds. Latin America is responsible for the greatest number of foreign currency defaults over the last five decades with more than 60% of defaults in each decade with the exception of the 1990s. Over the last 200 years there are many instances of default. The defaults primarily occurred in seven distinct time periods: 1824–1834, 1867–1882, 1890–1900, 1911–1921, 1931–1940, 1976–1989, and 1998–2003. Thus, countries did borrow and default in the 19th century. (LO 24.c)

2. **C** Examining sovereign defaults leads to the following conclusions: (1) gross domestic product (GDP) growth falls between 0.5% and 2.0% following a sovereign default, and the decline is short lived, (2) ratings of countries that have defaulted at least once since 1970 are one to two grades lower than the ratings of similar countries that have not defaulted and borrowing costs are 0.5% to 1.0% higher with the effects lessening over time, (3) sovereign default can cause trade retaliation, lasting up to 15 years, with export businesses most sharply affected, (4) a banking crisis is more likely to follow a default, and (5) sharp currency devaluations and changes in a country's leadership often follow defaults. (LO 24.d)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Hull, Chapter 17.

READING 25

ESTIMATING DEFAULT PROBABILITIES

Study Session 5

EXAM FOCUS

This topic discusses various approaches for estimating default probabilities, which are used to calculate credit value at risk and determine counterparty credit risk. For the exam, understand how to interpret a rating migration matrix. Also, be aware of the relationships between borrowing ratings and the probability of default as well as recovery rates and default rates. Knowledge of credit default swap (CDS) mechanics and the associated calculations (e.g., up-front premium, hazard rates) is important, as is being able to calculate default probabilities from historical data and credit spreads. In addition, understand the differences between risk-neutral and real-world default probability estimates. Finally, be able to apply the Merton model to compute equity value, loss on debt, distance to default, and probability of default.

MODULE 25.1: CREDIT RATINGS AND DEFAULT PROBABILITIES

LO 25.a: Compare agencies' ratings to internal credit rating systems.

Credit ratings of larger publicly traded bond issuers are provided to the general public by rating agencies. Credit ratings are indicative of credit quality; therefore, they may change based on information (positive or negative) released to the market. When assigning ratings, rating agencies aim to provide stability to avoid frequent rating changes that might occur based on short-term information received. In other words, rating agencies take a long-term view of an issuer's creditworthiness. In that regard, "rating through an economic cycle" is an important consideration as information may be received that suggests a higher likelihood of default within the next year, but an overall insignificant change in default probability over the subsequent four years, for example.

Rating agencies typically do not provide credit ratings for small- and mid-sized firms. As a result, many lenders have developed their own internally developed credit rating systems for such firms. Internal credit rating systems usually look at profitability (e.g., return on equity), liquidity (e.g., quick ratio), and solvency (e.g., debt-to-equity ratio) measures. Because borrowings must be repaid with cash, lenders will use company-prepared financial statements as a starting point and make the required adjustments to create a cash flow statement. A cash flow statement is especially useful when determining a firm's repayment ability.

Altman's Z-Score

LO 25.b: Describe linear discriminant analysis (LDA), define the Altman's Z-score and its usage, and apply LDA to classify a sample of firms by credit quality.

Linear discriminant analysis (LDA) is a popular statistical method used for developing credit scoring models. A scoring function is a linear function of variables produced by an LDA. The variables are chosen based on their estimated contribution to the likelihood of default and come from an extensive pool of qualitative features and financial ratios.

Altman's Z-score is an application of LDA that is used to predict defaults. The following five financial ratios are used:

1. X_1: working capital / total assets
2. X_2: retained earnings / total assets
3. X_3: earnings before interest and taxes (EBIT) / total assets
4. X_4: market value of equity / book value of total liabilities
5. X_5: sales / total assets

Altman's Z-score was initially devised for publicly traded manufacturing firms. Its reliability has been confirmed by testing out-of-sample data and discovering few Type I and Type II errors. The Z-score model has also been adapted and refined for use with private manufacturing firms.

The contributions (weights) of each of the five financial ratios to the overall score are as follows:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$$

In applying LDA to classify firms based on credit quality, the guidelines regarding the computed Z-score are as follows:

- > 3: no default is likely
- 2.7–3: potential default
- 1.8–2.7: reasonable probability of default
- < 1.8: high likelihood of default

Thus, the higher (lower) the score, the more likely the firm will be classified as a solvent (insolvent).

Historical Default Probabilities

LO 25.d: Describe a rating migration matrix and calculate the probability of default, cumulative probability of default, and marginal probability of default.

S&P borrowing ratings range from AAA (highest rating; best quality) to D (lowest rating; in payment default). With this rating scale, *investment-grade bonds* are rated from AAA to BBB (best quality to good quality), while *non-investment-grade* (junk) bonds are rated from BB to D.

Figure 25.1 provides an example of a **rating migration matrix** developed by S&P covering a period of almost 40 years. This matrix quantifies the average default rates of issuers based on initial credit rating.

Figure 25.1: Cumulative Issuer-Weighted Default Rates for 1981–2020 (in %)

	Time Horizon (in Years)							
Rating	**1**	**2**	**3**	**4**	**5**	**7**	**10**	**15**
AAA	0.00	0.03	0.13	0.24	0.34	0.51	0.70	0.90
AA	0.02	0.06	0.11	0.21	0.30	0.49	0.70	0.99
A	0.05	0.13	0.22	0.33	0.46	0.76	1.20	1.84
BBB	0.16	0.43	0.75	1.14	1.54	2.27	3.24	4.54
BB	0.63	1.93	3.46	4.99	6.43	8.89	11.64	14.65
B	3.34	7.80	11.75	14.89	17.35	20.99	24.62	28.24
CCC/C	28.30	38.33	43.42	46.36	48.58	50.75	52.76	54.76

Source: S&P Global Ratings Research

From the data in Figure 25.1, a bond that begins with an AA rating has a 0.02% chance of defaulting by the end of the first year, a 0.06% chance of defaulting by the end of the second year, a 0.11% chance of defaulting by the end of the third year, and so on. These values represent the **cumulative probability of default**. Based on those amounts, it is possible to calculate the **marginal probability of default**. For example, the probability of an AA-rated bond defaulting *within* its third year is computed as 0.11% (cumulative probability to the end of Year 3) minus 0.06% (cumulative probability to the end of Year 2), which is equal to 0.05%.

Borrowing Rating vs. Probability of Default

LO 25.c: Describe the relationship between borrower rating and probability of default.

In general, the lower (higher) the borrowing rating, the greater (lower) the probability of default. Furthermore, for investment-grade bonds and some non-investment-grade

bonds, the (marginal) probability of default in a given year will increase with time during the initial years. In other words, the assumption is that the issuer is assumed to be stable at the outset, but with time, there is an increased potential of financial deterioration. Using the example of a bond with a baseline rating of AA, the marginal probabilities of default in Years 1, 2, and 3 are 0.02%, 0.04%, and 0.05%, respectively.

Additionally, for other categories of non-investment-grade bonds, it may be the case that the marginal probabilities of default start to decrease with time because the initial years are critical in terms of survival. The assumption is that if the issuer has not defaulted within the initial years, then its financial state may not be as precarious as initially assessed. Using the example of a bond with a baseline rating of B, the marginal probabilities of default in Years 1, 2, 3, and 4 are 3.34%, 4.46%, 3.95%, and 3.24%, respectively. Notice that after an increase in default probability in Year 2 over Year 1, the default probabilities in subsequent years show a consistent declining trend.

Hazard Rates

LO 25.e: Define the hazard rate and use it to define probability functions for default time as well as to calculate conditional and unconditional default probabilities.

Using the rating migration matrix information in Figure 25.1, we have already shown the calculation for an **unconditional default probability**, which is the marginal probability of default. For example, using the BB-rated bond, the unconditional default probability in Year 4 (from a Year 0 perspective) is 1.53% (= 4.99% − 3.46%).

The probability that the BB-rated bond remains in place until the end of Year 3 is 96.54% (= 100% − 3.46%). The **conditional default probability** (i.e., probability that the bond will default in Year 4, conditional on no earlier default) is then computed as 1.58% (= 1.53% / 96.54%). If one year is considered a sufficiently short amount of time, then the conditional default probability could also be called the **hazard rate** of default intensity.

The following equation can be used to calculate the **probability of default** by time *t*:

$$Q(t) = 1 - e^{-\bar{\lambda}(t)\times t}$$

where:

$\bar{\lambda}(t)$ = average hazard rate between time 0 and time *t*

Note that only the average hazard rate between t = 0 and *t* is required, because it is assumed to be a constant parameter. Assuming a constant hazard rate of 2% per year, the probability of default by the end of Year 1 (t = 1) is 1.98% (= $1 - e^{-0.02\times 1}$) and by the end of Year 2 (t = 2) is 3.92% (= $1 - e^{-0.02\times 2}$).

Continuing the computations just listed with the assumed 2% hazard rate, the probability of default by the end of Year 4 is 7.69% (= $1 - e^{-0.02\times 4}$). By the end of Year 5, it is 9.52% (= $1 - e^{-0.02\times 5}$). This means that the unconditional probability of default during Year 5 is equal to 1.83% (= 9.52% − 7.69%). It also means that the conditional

probability of default in Year 5, conditional on no earlier default, is 1.98% [= 1.83% / (1 – 7.69%)].

Recovery Rates

LO 25.f: Describe recovery rates and their dependencies on default rates.

When an issuer files for bankruptcy, most of the creditors are unlikely to receive full repayment of the face value of their claims. In that regard, a bond's **recovery rate** becomes relevant and can be thought of as the trading price as a fraction of the face value approximately a month following default. Figure 25.2 provides a summary of average recovery rates for six classes of bonds.

Figure 25.2: Recovery Rates on Corporate Bonds for 1983–2021

Class	Average Recovery Rate (%)
First lien bond	54.6
Second lien bond	44.3
Senior unsecured bond	38.0
Senior subordinated bond	31.0
Subordinated bond	32.1
Junior subordinated bond	22.3

Source: Moody's

From this information, it makes sense that the more senior bonds (e.g., first lien bond at 54.6% average recovery rate) have higher recovery rates than more junior bonds (e.g., subordinated bond at 32.1% average recovery rate).

Note that the recovery rate on debt is negatively correlated to the default rate. This can clearly be demonstrated with mortgages in that higher mortgage default rates mean more foreclosures and more properties for sale in the market. That, in turn, will lead to a decline in property prices, which reduces the lender's recovery rate.

Similarly with bonds, a strong economy usually has few bond defaults—but when there is a default, the average recovery rate is relatively high because of the strong economy. However, a weak economy usually has more bond defaults—and when there is a default, the average recovery rate is relatively low because of the weak economy. In short, the negative correlation between default rates and recovery rates is especially challenging for lenders in a weak economy because there are both high default rates and low recovery rates.

MODULE QUIZ 25.1

1. The following financial data pertains to Nielsen Corp. (Nielsen):

Working capital	$525,000
Total assets	$5,100,000
Book value of liabilities	$1,850,000
Market value of liabilities	$2,050,000
Retained earnings	$1,120,000
Market value of equity	$4,215,000
Earnings before interest and taxes	$480,000
Sales	$1,760,000

The Altman's Z-score equation is as follows:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$$

When using the computed Z-score to classify Nielsen based on credit quality, what is the most appropriate classification for the company?

A. No default is likely.
B. Potential default.
C. Reasonable probability of default.
D. High likelihood of default.

2. The following information is an excerpt from a rating migration matrix for a B-rated bond:

Time Horizon	Average Cumulative Default Rate
1 year	3.34%
2 years	7.80%
3 years	11.75%
4 years	14.89%
5 years	17.35%

What is the probability that the bond will default during the fourth year conditional on no earlier default?

A. 2.46%.
B. 2.79%.
C. 3.14%.
D. 3.56%.

MODULE 25.2: CREDIT DEFAULT SWAPS

LO 25.g: Define a credit default swap (CDS) and explain its mechanics including the obligations of both the default protection buyer and the default protection seller.

A **credit default swap (CDS)** is a credit derivative that is similar to a typical swap in that one party makes payments to another party. The purchaser of the CDS seeks credit protection (i.e., default protection buyer) and will usually make fixed quarterly payments (in advance) to the seller of the CDS (i.e., default protection seller) for the life

of the swap, or until a credit event occurs. Credit events may include nontimely payment, debt restructuring, or bankruptcy.

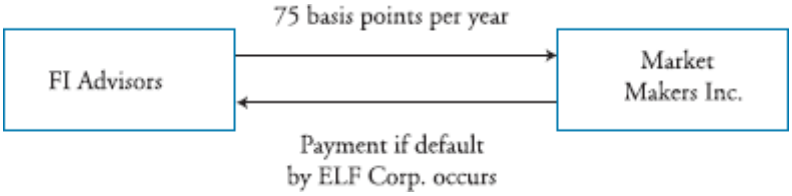
The underlying "reference entity" in a CDS is the firm in question, and the CDS protection buyer is concerned that a credit event (e.g., default) may occur at this firm. If default occurs, and assuming the terms of the swap agreement dictate settlement by physical delivery, the swap will be settled with the seller of the CDS paying the buyer the face value (notional principal) of the bonds and receiving the bonds in exchange.

To illustrate, suppose FI Advisors (FIA) owns fixed-income securities issued by ELF Corp. (ELF, the reference entity) with a par value of $200 million. FIA would like to protect its position against credit risk by using a CDS and is able to purchase such protection from Market Makers, Inc. (MM) for 75 basis points (i.e., the CDS spread) of a notional principal of $200 million on September 20, 2024. The life of the CDS is five years, which will require FIA to pay the equivalent of $1.5 million (= $200 million × 0.0075) to MM every year (or about $375,000 per quarter on the standard maturity dates of March 20, June 20, September 20, and December 20).

If ELF does not default, then FIA receives nothing from the swap. If ELF does default on July 20, 2028, for example, MM will pay FIA the notional principal of $200 million and receive the ELF bonds (assuming physical settlement). Note that the CDS contract likely provides a list of acceptable bonds (e.g., same seniority) that may be delivered upon default but sell at different percentages of face value. This introduces the possibility of the **cheapest-to-deliver (CTD) bond**. In the case of cash settlement, dealers are surveyed a specified number of days following a credit event to determine the midpoint between bid and ask prices of the CTD bond. If that CTD bond is valued at $0.40 to the dollar, then the cash payoff would be 60% or $120 million in this example.

Additionally, the protection buyer pays the ongoing premium to the protection seller only until there is a credit event. Using the example of a July 20, 2028 default and payment in arrears, then a final accrual payment of about $125,000 (= $375,000 per quarter × 1/3) to cover the one-month period from June 20, 2028 to July 20, 2028 would be required—and then the premium payments would cease. The example CDS transaction structure is illustrated in Figure 25.3.

Figure 25.3: Credit Default Swap Example



CDS contracts are traded with maturities that include 1, 2, 3, 5, 7, and 10 years, with 5 years being the most common in practice. Because of the standard maturity dates mentioned earlier, the actual life of the CDS contract might not be identical to the stated life, but it will be close. For example, a CDS that is initiated on August 10, 2025 would probably mature on September 20, 2030. The first payment due on September 20, 2025 would be an accrual amount to account for the period from August 10 to

September 20, 2025. Subsequently (e.g., December 20, 2025 payments and onward), the quarterly payments would be fixed.

Credit Indices

There are two well-known investment-grade **credit indices**, each with 125 reference entities. Maturities of 3, 5, 7, and 10 years (likely on June 20 and December 20) are most common. Those two portfolios are:

- CDX NA IG (North America) and
- iTraxx Europe.

To demonstrate the payment structure for credit indices, suppose that the 5-year iTraxx Europe index is quoted as bid 150 bps and ask 152 bps. Assuming an investor seeks €500,000 of protection per firm, using the ask price, it means that there are total annual payments of 0.0152 × €500,000 × 125 = €950,000. Or, if an investor sells €500,000 of protection per firm, using the bid price, it means total annual receipts of 0.015 × €500,000 × 125 = €937,500.

Assuming the purchase of protection, if one reference entity defaults, then the investor receives the appropriate payoff as well as a future reduction in the annual payments of €7,600 (= €950,000 / 125).

Fixed Coupons

In a CDS contract, the protection buyer pays a regular fixed coupon to the protection seller periodically over the life of the contract in return for a payment upon a prespecified credit event or reference entity (or entities). The fixed coupon paid periodically by the protection buyer is standardized to 100 basis points (i.e., 1%) for investment-grade issuers, because standardizing the regular payment in this way makes settlement and clearing of contracts more straightforward. It is important to note that this standardized coupon is not the fair premium (i.e., CDS spread) that should be regularly paid by the protection buyer.

In terms of an **up-front premium**, there are three possibilities:

1. CDS spread = fixed coupon; no up-front premium
2. CDS spread > fixed coupon; up-front premium equal to the present value of (CDS spread - fixed coupon) paid by protection buyer to protection seller
3. CDS spread < fixed coupon; up-front premium equal to the present value of (CDS spread - fixed coupon) paid by protection seller to protection buyer

CDS Spreads

LO 25.h: Describe CDS spreads and explain how CDS spreads can be used to estimate hazard rates.

The **CDS spread** is essentially the price of the CDS expressed in basis points. Using the previous example of 150 basis points (i.e., 1.5%), credit protection on the specific

underlying debt requires a payment of 1.5% from the protection buyer. In other words, the credit protection seller requires a 1.5% premium for bearing the credit risk.

The **bond yield spread** is the excess of the corporate bond yield over a comparable risk-free bond. In theory, the CDS spread and the bond yield spread should be equal. Putting everything together, a 5-year corporate bond with a 6% annual yield might be hedged using a 5-year CDS with a CDS spread of 1.5%. Netting the two positions produces a riskless position in the form of a net return of 4.5% (implied risk-free rate) to the investor, assuming no bond default. Or, in the event of a bond default, the return is 4.5% until default. After default, the investor will receive the face value of the bond, which can be invested at the risk-free rate until the end of the five years:

- If CDS spread < bond yield spread, buy the corporate bond, and buy CDS protection to earn more than the risk-free rate
- If CDS spread > bond yield spread, sell the corporate bond, and sell CDS protection to borrow at less than the risk-free rate

Note that this discussion has focused on fixed rates. Asset swaps and asset swap spreads provide direct estimates of the bond yield increment above a market reference rate (e.g., floating rate).

CDS-Bond Basis

LO 25.i: Define and explain CDS-bond basis.

The **CDS-bond basis** is defined as:

CDS-bond basis = CDS spread - bond yield spread

As mentioned, the CDS-bond basis should be zero (or near zero) because the CDS spread and the bond yield spread should be equal. In practice, however, this is not always the case due to the following reasons:

- Bonds may sell for much higher than par (negative basis) or lower than par (positive basis).
- CDSs are subject to counterparty risk (negative basis).
- A CTD possibility exists with a CDS (positive basis).
- CDS payoffs exclude accrued interest (negative basis).
- CDS contracts may contain a restructuring clause that allows for payoffs, even without default (positive basis).
- The bond yield spread is computed using a risk-free rate that is dissimilar to the one used by the market.

Due to constraints caused by illiquidity, arbitrage opportunities involving bonds and CDSs cannot always be fully exploited, which may also result in a nonzero basis. The CDS-bond basis was generally positive before the financial crisis of 2007–2009 but has since become negative and less significant.

Approximating Hazard Rates

An approximate calculation of the hazard rate based on credit spreads (e.g., CDS spreads or bond yield spreads), which can be used for a bond that trades near par value, is expressed as:

$$\bar{\lambda} = \frac{s(T)}{1 - RR}$$

where:

$\bar{\lambda}$ = average hazard rate
$s(T)$ = credit spread for maturity T
RR = recovery rate

For example, assume that an issuer's 5-year credit spread is 210 basis points (i.e., annual expected loss of 2.1%) and that the expected recovery rate in the event of a default is 30%. This suggests that the average probability of a default per year over five years, conditional on no earlier default, is equal to 0.021 / (1 − 0.3) = 3%.

This example could be expanded to bootstrap a term structure of the hazard rate using credit spreads for numerous maturities. Assume that spreads for 3-, 5-, and 10-year CDSs are 80, 90, and 110 bps, respectively, and that the expected recovery rate is 65%:

- Average hazard rate over 3 years: 0.008 / (1 − 0.65) = 0.0229 (or 2.29%)
- Average hazard rate over 5 years: 0.009 / (1 − 0.65) = 0.0257 (or 2.57%)
- Average hazard rate over 10 years: 0.011 / (1 − 0.65) = 0.0314 (or 3.14%)

Therefore, the average hazard rate between Year 3 and Year 5 is:

[(5 × 0.0257) − (3 × 0.0229)] / 2 = 0.0299, or 2.99%

The average hazard rate between Year 5 and Year 10 is:

[(10 × 0.0314) − (5 × 0.0257)] / 5 = 0.0371, or 3.71%

More Precise Hazard Rates

A more precise calculation of hazard rates should be used for a bond that does not trade near its par value. Assume a 5-year risky corporate bond with 6% annual coupons paid semiannually that yields 7% annually on a continually compounded basis. The risky bond would be priced at 95.34 (assuming 100 face value). Also, assume a risk-free government bond with 6% annual coupons paid semiannually that yields 5% annually on a continually compounded basis. The risk-free bond would be priced at 104.09. As a result, the price difference of 8.75 (risk-free vs. risky bond) is the expected loss from default over the bond term.

Figure 25.4 provides a summary of calculations of the present value of the expected loss on the assumption that defaults can only occur at five specified times that are immediately before coupon payment dates. The recovery rate is assumed to be 40%, and the default probability is denoted as Q and assumed to be constant for the entire life of the bond.

Figure 25.4:Expected Loss From Bond Default ($100 Notional)

Time (Years)	Default Probability	Recovery Amount ($)	Default-Free Value ($)	Loss ($)	Discount Factor	PV of Expected Loss ($)
0.5	Q	40	106.73	66.73	0.9753	65.08Q
1.5	Q	40	105.97	65.97	0.9277	61.20Q
2.5	Q	40	105.17	65.17	0.8825	57.52Q
3.5	Q	40	104.34	64.34	0.8395	54.01Q
4.5	Q	40	103.46	63.46	0.7985	50.67Q
Total						288.48Q

The expected value of a default-free bond at t = 4.5 years is 103.46, which is calculated as:

$$3 + 103e^{-0.05\times0.5} = 103.46$$

Based on a recovery rate of 40% of the face value, the loss given default (LGD) is 63.46 (= 103.46 − 40), and on a discounted basis using a 5% annual discount rate, the loss is 50.67 and the expected loss is 50.67Q.

Based on the information in Figure 25.4, the total expected loss for all the periods is 288.48Q. Given the 8.75 amount computed earlier, the default probability (Q) = 8.75 / 288.48 = 3.03%.

Using a sample of bonds maturing in 2, 5, and 7 years, a bootstrapping process could be used for estimating the term structure of default probabilities. The 2-year bond could be used to estimate the default probability for the first two years, the 5-year bond to estimate the annual default probabilities for Years 4 and 5, and the 7-year bond to estimate the annual default probabilities for Years 6 and 7.

MODULE QUIZ 25.2

1. The five-year CDX NA IG Index (125 companies) is quoted as bid 141 bps and ask 143 bps. An investor plans to sell $1 million of protection on each company. At the beginning of the third year before the annual protection payment, one of the companies defaults. Assuming no other defaults, the investor's cash flow for the third year is closest to:
   A. $748,400 inflow.
   B. $748,400 outflow.
   C. $773,200 inflow.
   D. $773,200 outflow.

2. In the context of arbitrage trades, if the CDS spread is significantly greater than the bond yield spread, what is the most appropriate action by the investor?
   A. Buy the corporate bond and buy CDS protection.
   B. Buy the corporate bond and sell CDS protection.
   C. Sell the corporate bond and buy CDS protection.

D. Sell the corporate bond and sell CDS protection.

MODULE 25.3: COMPARING DEFAULT PROBABILITIES

LO 25.j: Compare default probabilities calculated from historical data with those calculated from credit yield spreads.

Figure 25.5 provides the 7-year average cumulative default probabilities for issuers of varying credit ratings (from S&P in Column 1) and the 7-year credit spread for varying ratings (from Merrill Lynch in Column 2).

Figure 25.5: Comparing Cumulative Default Probabilities With Credit Spreads

Rating	Cumulative 7-Year Default Probabilities (%): 1981–2020	7-Year Credit Spread (bps): 1996–2007
AAA	0.51	35.74
AA	0.49	43.67
A	0.76	68.68
BBB	2.27	127.53
BB	8.89	280.28
B	20.99	481.04
CCC/C	50.75	1,103.70

The amounts in Figure 25.5 can be used to estimate the average 7-year hazard rates. There are two methods for making these calculations. The first method applies the following equations:

$$Q = 1 - e^{-7\bar{\lambda}}$$

$$\bar{\lambda}(7) = -\frac{1}{7}\ln(1 - Q)$$

Method 1: A BBB-rated issuer has a cumulative 7-year default rate of 2.27%, so the average hazard rate is calculated as:

$$\bar{\lambda}(7) = -\frac{1}{7}\ln(1 - 0.0227) = 0.00328 = 0.328\%$$

Method 2: Using the same BBB-rated issuer as Method 1, but using the 7-year credit spread and a 40% recovery rate assumption, the average 7-year hazard rate is:

$$\bar{\lambda}(7) = 0.012753 \,/\, (1 - 0.4) = 0.02126 = 2.126\%$$

A summary of the average 7-year hazard rates is provided in Figure 25.6 for the full range of credit ratings using the same methodologies just discussed.

Figure 25.6: Hazard Rates Differences

Rating	Rate From Default Probabilities (%)	Rate Implied by Credit Spreads (%)	Difference
AAA	0.073	0.596	0.523
AA	0.070	0.728	0.658
A	0.109	1.145	1.036
BBB	0.328	2.126	1.798
BB	1.330	4.671	3.341
B	3.366	8.017	4.651
CCC/C	10.118	18.395	8.207

Based on the rate comparisons in Figure 25.6, the hazard rates computed from credit spreads are significantly greater than those computed from historical data. As credit quality improves (worsens), the differences are less (greater). A simple conclusion here is that the return for bearing credit risk is more than sufficient because the return is greater than the expected cost of the defaults. Such excess return is even more prevalent when transacting in lower-credit-quality instruments and during periods of economic turmoil with high credit spreads.

The key explanation for these hazard rate calculations is that bond defaults are not independent and often depend on economic conditions; on a stand-alone basis, a good (bad) economy decreases (increases) default probabilities. Historical data suggests a wide range of default rates from year to year, and this variation results in *systematic risk* (risk that is nondiversifiable) whereby the market provides investors with a return premium for taking on the additional risk. With lower-quality debt being analogous to equity, it makes sense for the expected return (and consequently, excess return) on such debt to increase.

Additionally, it may not be possible or even practical to fully diversify away all the unsystematic risk in a bond portfolio (e.g., compared to an equity portfolio). In fact, taking on the unsystematic risk may provide additional return to the investor. Finally, a relatively minor point to consider for higher credit spreads is that corporate bonds are less liquid, which suggests a liquidity premium for bearing such risk.

Real-World vs. Risk-Neutral Default Probabilities

LO 25.k: Describe the difference between real-world and risk-neutral default probabilities and determine which one to use in the analysis of credit risk.

Under risk neutrality, the risk-free rate is assumed to be the expected growth rate of the firm's assets, whereas in the real world, the expected growth rate is the risk-free rate plus a market risk premium. Therefore, all things being equal, the computed asset values will be higher in the real world compared to risk neutrality.

The result is that assuming the same face value of debt, the **real-world default probability** will be lower than the **risk-neutral default probability** due to the higher asset valuation of real-world probabilities. For valuation purposes, risk-neutral

estimates (e.g., estimates of default rates from credit spreads) make sense because no additional premium is required for bearing risk. In contrast, for scenario analysis, real-world estimates (e.g., default estimates from historical data) would be more appropriate.

Default Probability Estimation With the Merton Model

LO 25.l: Using the Merton model, calculate the value of a firm's debt and equity, the volatility of firm value, and the volatility of firm equity.

LO 25.m: Using the Merton model, calculate distance to default and default probability.

The **Merton model** views firm equity value as a long call option on the firm's assets. For this model, we assume that there is debt outstanding that needs to be repaid at time *T*. Terminology for the Merton model is expressed as follows:

- V_0 = current value of the firm's assets
- V_T = value of the firm's assets at time *T*
- D = total debt to be repaid at time *T*
- E_0 = current value of the firm's equity
- E_T = value of the firm's equity at time *T* (i.e., V_T - D)
- σ_V = asset volatility
- σ_E = equity volatility

In the Merton model, the strike price of the call option is the total debt to be repaid (D). Therefore, $E_T = \max(V_T - D, 0)$ because if $V_T > D$, it makes sense to continue to service the debt and retain the positive value of E_T. From a purely quantitative perspective, if $V_T < D$, then it makes sense to default on the debt because the value of the equity is zero.

On the assumption of no dividends, the Black-Scholes-Merton equity value today is stated as:

$$E_0 = V_0 N(d_1) - De^{-rT} N(d_2)$$

where:

$$d_1 = \frac{\ln(V_0/D) + (r + \sigma_v^2/2)T}{\sigma_v \sqrt{T}}$$

$$d_2 = d_1 - \sigma_v \sqrt{T}$$

N = cumulative normal distribution function

When the option is not exercised, there is a default by the firm, and the probability of occurrence is denoted as $N(-d_2)$. Calculating that probability must be done indirectly and requires values for V_0 and σ_V. Stochastic calculus can be applied such that:

$$\sigma_E E_0 = \frac{\partial E}{\partial V}\sigma_V V_0$$

The delta of equity is equal to $\partial E / \partial V$, so $N(d_1)$ can be used as a substitute:

$$\sigma_E E_0 = N(d_1)\sigma_V V_0$$

Once V_0 and σ_V are solved, the remaining items of d_1, d_2, $N(d_1)$, and $N(-d_2)$ can be solved.

Putting it all together, assume a firm's current equity value is \$3 million ($E_0 = 3$) and its equity volatility is 80% ($\sigma_E = 0.80$). There is debt outstanding of \$10 million ($D = 10$) that needs to be repaid in one year ($T = 1$). The annual risk-free rate is assumed to be 5% ($r = 0.05$).

Assuming the appropriate calculations have been performed, it is determined that $V_0 = 12.40$ and $\sigma_V = 0.2123$. It is now possible to use the previous equations to determine the remaining values:

- Using the equation $\sigma_E E_0 = N(d_1)\sigma_V V_0$, with five variables and four known variables, it is possible to solve for the unknown variable of $N(d_1)$ as 0.9117.
- From there, apply the Black-Scholes-Merton equation and solve for unknown variable $N(d_2)$ as 0.873.
  - The (risk-neutral) *probability of default* is $N(-d_2) = 1 - N(d_2) = 1 - 0.873 = 0.127$.
  - The *distance to default* is d_2, which first requires the calculation of d_1; in this example, $d_1 = 1.3547$ and $d_2 = 1.1408$.
- The current market value of debt is $V_0 - E_0 = 12.40 - 3 = 9.40$. The discounted value of the debt repayment is $10e^{-0.05\times1} = 9.51$. This leads to the expected loss on the debt equal to $(9.51 - 9.40) / 9.51 = 1.2\%$.

Note that one of the key outputs from the Merton model is the **distance to default**, which is the number of standard deviations that the asset price must fall to lead to a default at time *T*. The higher (lower) the distance to default, the lower (higher) the probability of default. The distance to default, which is equal to d_2, can be computed directly as:

$$d_2 = \frac{\ln(V_0) - \ln(D) + (r - \sigma_V^2/2)T}{\sigma_V\sqrt{T}}$$

Merton Model Performance

LO 25.n: Assess the quality of the default probabilities produced by the Merton model, the Moody's KMV model, and the Kamakura model.

Empirical evidence supports that the Merton model, Moody's-KMV model, and the Kamakura model provide reliable and reasonably accurate rankings of default probabilities. The Merton model's output is a risk-neutral default probability because

of its derivation from an option pricing model. From there, **Moody's-KMV model** and the **Kamakura model** take the output from the Merton model and restate it in the form of a real-world default probability.

MODULE QUIZ 25.3

1. A junior analyst is evaluating the following questions to include in her research report:
   - Which type of default probabilities should be used in valuation?
   - What is the impact on a company defaulting when the distance to default rises?

   Regarding these questions, the analyst's report should support which of the following conclusions?

	Use in valuation	Rising distance to default
A.	Risk-neutral default probabilities	Company more likely to default
B.	Risk-neutral default probabilities	Company less likely to default
C.	Real-world default probabilities	Company more likely to default
D.	Real-world default probabilities	Company less likely to default

KEY CONCEPTS

LO 25.a

Credit ratings of larger publicly traded bond issuers are provided by rating agencies. These ratings are indicative of credit quality. Therefore, they may change based on information released to the market. Rating agencies typically do not provide credit ratings for small- and mid-sized firms. As a result, many lenders have developed their own internally developed credit rating systems for such firms. Internal credit rating systems usually look at profitability, liquidity, and solvency measures.

LO 25.b

Altman's Z-score is an application of linear discriminant analysis (LDA) that is used to predict defaults. The following five financial ratios are computed:

1. X_1: working capital / total assets
2. X_2: retained earnings / total assets
3. X_3: earnings before interest and taxes (EBIT) / total assets
4. X_4: market value of equity / book value of total liabilities
5. X_5: sales / total assets

The Z-score equation for publicly traded manufacturing firms is:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$$

LO 25.c

The lower (higher) the borrowing rating, the greater (lower) the probability of default. For investment-grade bonds and some non-investment-grade bonds, the (marginal) probability of default in a given year will increase with time during the initial years.

For non-investment-grade bonds, it may be the case that the marginal probabilities of default start to decrease with time because the initial years are critical in terms of survival.

LO 25.d

A rating migration matrix quantifies the average default rates of issuers based on an initial credit rating. Cumulative probabilities of default are provided by the matrix. Based on those amounts, it is possible to calculate the marginal probabilities of default.

LO 25.e

The following equation can be used to calculate the probability of default by time *t*:

$$Q(t) = 1 - e^{-\bar{\lambda}(t) \times t}$$

where:

$\bar{\lambda}(t)$ = average hazard rate between time 0 and time *t*

An approximate calculation of hazard rates used for a bond that trades near its par value is expressed as:

$$\bar{\lambda} = \frac{s(T)}{1 - RR}$$

where:

$\bar{\lambda}$ = average hazard rate
$s(T)$ = credit spread for maturity T
RR = recovery rate

A more precise calculation of hazard rates should be used for a bond that does not trade near its par value.

LO 25.f

A bond's recovery rate can be thought of as the trading price as a fraction of the face value approximately a month following default. More senior bonds have higher recovery rates than more junior bonds. The recovery rate on debt is negatively correlated to the default rate.

LO 25.g

A credit default swap (CDS) is a credit derivative that is similar to a typical swap in that one party makes payments to another party. The purchaser of the CDS seeks credit protection and will usually make fixed quarterly payments (in advance) to the seller of the CDS for the life of the swap, or until a credit event occurs. Credit events may include nontimely payment, debt restructuring, and bankruptcy.

The underlying reference entity in a CDS is the firm in question. If default occurs, and assuming the terms of the swap agreement dictate settlement by physical delivery, the swap will be settled with the seller of the CDS paying the buyer the face value (notional principal) of the bonds and receiving the bonds in exchange. In terms of an up-front premium, there are three possibilities:

- CDS spread = fixed coupon; no up-front premium

- CDS spread > fixed coupon; up-front premium equal to the present value of (CDS spread - fixed coupon) paid by protection buyer to protection seller
- CDS spread < fixed coupon; up-front premium equal to the present value of (CDS spread - fixed coupon) paid by protection seller to protection buyer

LO 25.h

The CDS spread is essentially the price of the CDS expressed in basis points. The bond yield spread is the excess of the corporate bond yield over a comparable risk-free bond. In theory, the CDS spread and the bond yield spread should be equal:

- If CDS spread < bond yield spread, buy the corporate bond, and buy CDS protection to earn more than the risk-free rate
- If CDS spread > bond yield spread, sell the corporate bond, and sell CDS protection to borrow at less than the risk-free rate

LO 25.i

The CDS-bond basis should be zero because the CDS spread and the bond yield spread should be equal. In practice, this may not be the case due to the following reasons:

- Bonds may sell for much higher or lower than par.
- CDSs are subject to counterparty risk.
- A CTD possibility exists with a CDS.
- CDS payoffs exclude accrued interest.
- CDS contracts may contain a restructuring clause that allows for payoffs, even without default.
- The bond yield spread is computed using a risk-free rate that is dissimilar to the one used by the market.

LO 25.j

The hazard rates computed from credit spreads are significantly greater than those computed from historical data. As credit quality improves (worsens), the differences are less (greater). A conclusion is that the return for bearing credit risk is more than sufficient because the return is greater than the expected cost of the defaults. Such excess return is even more prevalent when transacting in lower-credit-quality instruments and during periods of economic turmoil with high credit spreads.

The key explanation is that bond defaults are not independent and often depend on economic conditions; on a stand-alone basis, a good (bad) economy decreases (increases) default probabilities.

LO 25.k

Under risk neutrality, the risk-free rate is assumed to be the expected growth rate of the firm's assets—whereas in the real world, the expected growth rate is the risk-free rate plus a market risk premium.

For valuation purposes, risk-neutral estimates (e.g., estimates of default rates from credit spreads) make sense because no additional premium is required for bearing risk.

In contrast, for scenario analysis, real-world estimates (e.g., default estimates from historical data) would be more appropriate.

LO 25.l

The Merton model views firm equity value as a long call option on the firm's assets. Terminology for this model is as follows:

- V_0 = current value of the firm's assets
- V_T = value of the firm's assets at time *T*
- D = total debt to be repaid at time *T*
- E_0 = current value of the firm's equity
- E_T = value of the firm's equity at time *T* (i.e., V_T - D)
- σ_V = asset volatility
- σ_E = equity volatility

In the Merton model, the strike price of the call option is the total debt to be repaid (D). Therefore, $E_T = \max(V_T - D, 0)$ because if $V_T > D$, it makes sense to continue to service the debt and retain the positive value of E_T. From a purely quantitative perspective, if $V_T < D$, then it makes sense to default on the debt because the value of the equity is zero.

LO 25.m

To estimate default probability using equity prices, apply the Black-Scholes-Merton equation to solve for unknown variable $N(d_2)$. From there, using the relationship of $N(-d_2) = 1 - N(d_2)$, it is possible to solve for $N(-d_2)$, which is the (risk-neutral) probability of default.

The distance to default (d_2) can be calculated directly using the Black-Scholes-Merton equation. Distance to default is the number of standard deviations that the asset price must fall to lead to a default at time *T*. The higher (lower) the distance to default, the lower (higher) the probability of default.

LO 25.n

Empirical evidence supports that the Merton model, Moody's-KMV model, and the Kamakura model provide reliable and reasonably accurate rankings of default probabilities. Moody's-KMV and Kamakura take the risk-neutral output from the Merton model and restate it in the form of real-world default probabilities.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 25.1

1. **C** The five financial ratios for computing Altman's Z-score are as follows:
    1. X_1: working capital / total assets = 525,000 / 5,100,000

2. X_2: retained earnings / total assets = 1,120,000 / 5,100,000
3. X_3: earnings before interest and taxes (EBIT) / total assets = 480,000 / 5,100,000
4. X_4: market value of equity / book value of total liabilities = 4,215,000 / 1,850,000
5. X_5: sales / total assets = 1,760,000 / 5,100,000

Altman's Z-score is then as follows:

Z = 1.2 × (525,000 / 5,100,000) + 1.4 × (1,120,000 / 5,100,000) + 3.3 × (480,000 / 5,100,000) + 0.6 × (4,215,000 / 1,850,000) + 0.999 × (1,760,000 / 5,100,000)

= 0.1235 + 0.3075 + 0.3106 + 1.3670 + 0.3448 = 2.4534

The following guidelines apply for assessing credit quality:

- > 3: no default is likely
- 2.7–3: potential default
- 1.8–2.7: reasonable probability of default
- < 1.8: high likelihood of default

Therefore, with a Z-score of 2.4534, Nielsen has a reasonable probability of default. (LO 25.b)

2. **D** The probability of a B-rated bond defaulting in the fourth year is 14.89% – 11.75% = 3.14%.

   The probability that the bond will survive until the end of the third year is 100% – 11.75% = 88.25%.

   Thus, the probability that the bond will default during the fourth year conditional on no earlier default is computed as 3.14% / 88.25% = 3.56%. (LO 25.d)

Module Quiz 25.2

1. **A** The investor will sell CDS protection on the 125 companies in the index for 140 bps per company. The annual receipt by the seller is 0.0141 × $1,000,000 × 125 = $1,762,500. However, because one company defaulted before the protection payment, the annual receipt by the CDS seller will be reduced by $1,762,500 / 125 = $14,100. In addition, the seller will have to pay $1 million to the CDS protection buyer as a result of the default. The CDS seller's cash inflow for the year is computed as $1,762,500 – $14,100 – $1,000,000 = $748,400. (LO 25.g)

2. **D** If the CDS spread is greater than the bond yield spread, sell the corporate bond, and sell CDS protection to borrow at less than the risk-free rate. (LO 25.h)

Module Quiz 25.3

1. **B** Risk-neutral default probabilities should be used in valuation, and real-world default probabilities should be used in scenario analysis. As the distance to default rises (falls), the company is less (more) likely to default. (LO 25.m)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Hull, Chapter 19.

READING 26

CREDIT VALUE AT RISK

Study Session 5

EXAM FOCUS

Credit value at risk (VaR) represents the credit loss over a certain time horizon that will not be exceeded given a specific level of confidence. For the exam, understand the differences between credit VaR and market VaR calculations. Also, interpreting a rating transition matrix is important, as that is often used in credit risk modeling. In addition, be familiar with the primary methodologies associated with calculating credit VaR, which include Vasicek's Gaussian copula model, Credit Risk Plus, CreditMetrics, and the correlation model. Finally, understand the impact of credit spreads on calculating credit VaR.

MODULE 26.1: DEFINING CREDIT VaR

Market VaR vs. Credit VaR

LO 26.a: Compare market risk value at risk (VaR) with credit VaR in terms of definition, time horizon, and tools for measuring them.

Credit risk VaR is defined as the credit risk loss that will not be exceeded over a given period of time within a specific level of confidence. Models can consider losses due to defaults, downgrades, and/or credit spread changes. Credit risk VaR is often used by banks to determine the amount of economic and regulatory capital.

Although credit risk VaR is similar to market risk VaR, there are some important differences, including:

- *Time horizon*. Market risk VaR is usually calculated with a one-day time horizon while credit risk VaR often uses a one-year time horizon.
- *Calculation tools*. While historical simulation is the primary tool for calculating market risk VaR, more elaborate modeling tools are often needed for credit risk VaR calculations.

Factors for Calculating Credit VaR

LO 26.b: Define and calculate credit VaR.

The following sections will describe methodologies that can be used to calculate credit VaR. Models for computing credit VaR must account for credit correlation, which is a recognition that defaults for different companies are not independent of one another. A strong economy will generally have a positive impact on companies such that default risk is lessened. However, a poor economy will have a negative impact on companies, which suggests that defaults will be more prominent. As credit correlation increases during economic downturns, financial institution risks will also increase.

LO 26.c: Describe the use of rating transition matrices for calculating credit VaR.

Rating transition matrices are often used by financial institutions when determining credit VaR. These matrices are based on historical data and reflect the likelihood that a company will migrate among rating categories over a given period of time. Figure 26.1 illustrates an actual one-year transition matrix published by S&P based on companies rated between 1981 and 2020.

Figure 26.1: One-Year Rating Transition Matrix for 1981–2020 (in %)

Initial Rating	Year-End Rating							
	AAA	AA	A	BBB	BB	B	CCC/C	D
AAA	89.85	9.35	0.55	0.05	0.11	0.03	0.05	0.00
AA	0.50	90.76	8.08	0.49	0.05	0.06	0.02	0.02
A	0.03	1.67	92.61	5.23	0.27	0.12	0.02	0.05
BBB	0.00	0.10	3.45	91.93	3.78	0.46	0.11	0.17
BB	0.01	0.03	0.12	5.03	86.00	7.51	0.61	0.70
B	0.00	0.02	0.08	0.17	5.18	85.09	5.66	3.81
CCC/C	0.00	0.00	0.12	0.20	0.65	14.72	50.90	33.42
D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

The interpretation of this matrix is fairly straightforward, assuming rating changes are independent across periods. The highest probabilities are associated with a company maintaining its rating by year-end, as evidenced by the shaded boxes in Figure 26.1. For example, a company starting the year with an AA rating has a 90.76% chance of keeping its AA rating. For that same company (reading along the AA initial rating row), there is a 0.50% chance it gets upgraded to AAA and an 8.08% chance it gets downgraded to A.

To extend the analysis beyond one year, the matrix can be multiplied by itself. In other words, a three-year transition matrix is the third power of the one-year matrix. For example, given the 89.85% probability that a AAA-rated company keeps its rating over one year, there is a 72.54% chance it keeps its rating over three years (i.e., $0.8985^3 = 0.7254$).

Alternatively, a time period less than one-year can also be considered. A three-month period requires taking the fourth root for the percentages displayed in Figure 26.1. Using the same 89.85% probability as noted earlier, there is a 97.36% chance that the company will keep its AAA rating over three months (i.e., $0.8985^{1/4} = 0.9736$).

Therefore, as the time period extends out further, default probabilities become higher and the odds of maintaining the same credit rating are lower. As time periods shorten, default probabilities will be lower and the odds of maintaining the same credit rating are higher.

Note that the independence criteria across periods may be challenging, as ratings momentum indicates that a company that has been recently downgraded is more likely to experience another downgrade.

MODULE QUIZ 26.1

1. Which of the following statements most accurately reflects the time horizons typically used for market VaR and credit VaR calculations?
   A. Both are calculated for one day.
   B. Both are calculated for one year.
   C. Market risk VaR is calculated over a longer time period than credit risk VaR.
   D. Credit risk VaR is calculated over a longer time period than market risk VaR.

2. During a period of slowing economic growth, an analyst will likely identify which of the following trends regarding credit correlation and financial institution risks?
   A. A decrease in credit correlation and defaults.
   B. An increase in credit correlation and defaults.
   C. An increase in credit correlation and a decrease in defaults.
   D. A decrease in credit correlation and an increase in defaults.

3. Historical data shows that over a one-year period, there is a 91.93% chance that a company rated BBB will keep its rating. What is the percentage chance this rating will remain unchanged over a four-year period?
   A. 36.77%.
   B. 67.72%.
   C. 71.42%.
   D. 95.97%.

MODULE 26.2: CREDIT VaR MODELS

Vasicek's Model

LO 26.d: Describe the application of the Vasicek model to estimate capital requirements under the Basel II internal-ratings-based (IRB) approach.

Vasicek's Gaussian copula model is a method used on a portfolio of loans to calculate high percentiles of the distribution of the default rate. The model outputs WCDR(T,X), which is the worst-case default rate during time period *T* at the *X*th percentile of the default rate distribution. The model relates the probability of default (PD) to the credit correlation (ρ) and time period *T*.

$$\text{WCDR}(T,X) = N\left(\frac{N^{-1}(PD) + \sqrt{\rho}N^{-1}(X)}{\sqrt{1-\rho}}\right)$$

The *X*th percentile of the loss distribution for an individual loan can be calculated by determining the WCDR for each loan and multiplying it by the exposure at default (EAD) and the loss given default (LGD). For a large portfolio with *n* small loans, the *X*th percentile of the loss distribution can be approximated as:

$$\sum_{i=1}^{n} \text{WCDR}_i(T,X) \times \text{EAD}_i \times \text{LGD}_i$$

The credit correlation (ρ) used in Vasicek's model should be approximately equivalent to the correlation between the two companies returns on assets (ROA) or returns on equities (ROE). Therefore, the average correlation between company ROEs could be used to determine ρ for a portfolio of exposures. Similar publicly traded companies' average correlation can be used as a proxy when the companies being valued are not publicly traded. One challenge of Vasicek's model (that can be alleviated by using alternate models) is the lack of incorporating tail correlation.

LO 26.e: Interpret the Vasicek's model, Credit Risk Plus (CreditRisk+) model, and the CreditMetrics ways of estimating the probability distribution of losses arising from defaults as well as modeling the default correlation.

Credit Risk Plus Model

Credit Suisse Financial Products developed a credit VaR calculation methodology called the **Credit Risk Plus** (a.k.a. CreditRisk+) **model**. Assuming independent defaults, a *binomial distribution* can be used to estimate the number of defaults (*m*). In this case, the probability of *m* defaults, with *n* loans and *q* probability of default of each loan, can be expressed as follows:

$$P(m \text{ defaults}) = \frac{n!}{m!(n-m)!} q^m (1-q)^{n-m}$$

An alternative calculation for when the probability of default is small, and the number of loans is large uses a *Poisson distribution* as follows:

$$P(m \text{ defaults}) = \frac{e^{-qn}(qn)^m}{m!}$$

Although the default probability (*q*) is unknown, a reasonable assumption is that the expected number of defaults (i.e., *qn*) will follow a *gamma distribution* (with mean μ and standard deviation σ). The Poisson distribution then becomes a *negative binomial distribution* as follows:

$$P(m \text{ defaults}) = p^m (1-p)^\alpha \frac{\Gamma(m+\alpha)}{\Gamma(m+1)\Gamma(\alpha)}$$

where:

$\alpha = \mu^2 / \sigma^2$

$p = \sigma^2 / (\mu + \sigma^2)$

$\Gamma(x)$ = the gamma function

The outcome of this modeling technique is that as σ decreases, the negative binomial distribution will follow the same probability distribution as the Poisson distribution. On the other hand, as σ increases, the likelihood of experiencing a large number of defaults increases.

Monte Carlo simulation is a way to incorporate default rate uncertainty into the modeling process. The reality is that the default rate in one year is unlikely to be independent of the default rate in the prior year. A model which ties the default rate in a given year to prior year default rates or economic elements from the prior year is desirable. As default rate uncertainty rises, the probability of large numbers of defaults rises because default correlation increases, and the loss probability distribution has a positive skew (vs. being symmetrical with low or no default correlation).

CreditMetrics Model

Vasicek's model and Credit Risk Plus only account for defaults and not downgrades. The **CreditMetrics model** (from JPMorgan) was designed to account for both defaults and downgrades. This model uses a rating transition matrix as described earlier, with ratings coming from either internal ratings (generated from historical bank data) or external credit rating agencies.

Monte Carlo simulation is needed for one-year credit VaR calculations on portfolios of transactions with multiple counterparties. Each trial involves determining counterparty credit ratings at the end of one year, with the credit loss calculated for each counterparty. If the credit rating at year-end for a specific counterparty equates to a default, the loss is equal to EAD multiplied by LGD (where LGD = 1 − the recovery rate). If the credit rating at year-end equates to no default, the credit loss calculation is the value of all transactions with that counterparty at the end of the year. The term structure of credit spreads for each rating category is needed for these calculations. This term structure is assumed to be either the same as what is observable in the market or based on a credit spread index.

Assume that a CreditMetrics simulation trial has no default during the first year. The term structure of credit spreads at the one-year point provides the probability of default in each time interval beginning in Year 1. The credit loss for each simulation trial can be calculated using the following formula:

$$\text{credit loss} = \sum_{i=j}^{n} (1 - \text{RR})(q_i^* - q_i)v_i$$

where:

jth interval begins at Year 1

RR = recovery rate

q_i = PD for the ith interval

q_i^* = PD for the ith interval ($i \geq j$) on a particular simulation trial

v_i = present value of expected net exposure (accounting for collateral) at the interval midpoint

An improvement in the counterparty's credit rating will likely produce a credit loss calculation that is negative. If a specific simulation trial produces a Year 1 default, the

loss will be determined by assessing the default timing and the EAD and then multiplying it by 1 − RR. The CreditMetrics Monte Carlo simulation produces a probability distribution for total credit losses from defaults and downgrades across all counterparties. The credit VaR is then derived using this distribution.

Correlation Model

In the **correlation model**, credit rating changes for unique counterparties are assumed to be related (not independent). A joint probability distribution of rating changes can be constructed using a Gaussian copula model, with the correlation between rating transitions for two companies equated to the correlation between their equity returns.

Using partial data from earlier Figure 26.1, if the correlation between two companies is 0.2, in random sampling two variables (x_A and x_B) with correlations of 0.2 from standard normal distributions, the probability of a rating change for an A-rated company is illustrated in Figure 26.2.

Figure 26.2: Partial Rating Transition Matrix (in %)

Initial Rating	Year-End Rating		
	AAA	AA	A
AAA	89.85	9.35	0.55
AA	0.50	90.76	8.08
A	0.03	1.67	92.61

$$N^{-1}(0.0003) = -3.3416$$
$$N^{-1}(0.0003 + 0.0167) = -2.1201$$
$$N^{-1}(0.0003 + 0.0167 + 0.9261) = 1.5813$$

So, if $x_A < -3.3416$, the A-rated company will get upgraded to AAA. If x_A is between −3.3416 and −2.1201, it will become AA-rated. The same exercise can be done for evaluating a B-rated company with a rating change, and then a comparison is done for the A-rated and B-rated companies transitioning to other ratings across the spectrum.

Note that any differences in predicted outcomes between the CreditMetrics and Credit Risk Plus models using the same assumptions are likely due to the predicted timing of losses.

Credit Spread Risk

LO 26.f: Define credit spread risk and assess its impact on calculating credit VaR.

Credit-sensitive products have values that naturally depend on credit spreads. Credit VaR calculations will therefore involve assessing potential credit spread changes. A historical simulation can be used to calculate a one-day 99% VaR, which can in turn be adjusted to calculate VaR over longer time periods. Scenarios may assume that credit spread changes stay consistent for companies. However, there are two problems with this approach: (1) the lack of daily credit spread updates and (2) the fact that currently

operating companies are unlikely to have defaulted in the past, so the assumption going forward is no default.

The CreditMetrics approach can be used here, where a rating transition matrix is developed over a specific period. Historical data on rating changes provide a probability distribution for credit spread changes over that same time period. Monte Carlo simulation is then used, where each trial samples the matrix to show whether a company keeps the same rating, changes to a different rating, or defaults. The credit spread for each rating category over that same time period will also be determined, which then facilitates a portfolio value for each trail as well as a credit VaR amount.

To introduce credit correlation, either a Gaussian copula model can be used for different company rating change correlations or rating category credit spread changes can be assumed to have very high correlations such that spreads for different rated instruments move in unison.

Suppose that a company holds a 3-year zero-coupon bond with a face value of $1,000. The risk-free rate is 2.5%, and the current credit spread is 150 basis points. The current price of the bond is computed as $1,000/(1.04)^3, or $889. The bond has a current rating of BBB and the probable ratings one month from now, along with the three equally likely credit spreads associated with the ratings, are as follows:

- *Rating increase to A:* 1.0% probability; credit spreads: 70, 90, and 110
- *No change to current rating (BBB)*: 97.6% probability; credit spreads: 120, 150, and 180
- *Rating decrease to BB:* 1.3% probability; credit spreads: 300, 350, and 400
- *Default:* 0.1% (assume the bond would be worth $300 if it defaults)

The outcomes of these scenarios are shown in Figure 26.3, assuming equal probabilities associated with the three potential credit spreads assigned to each rating. For a 3-year bond, one month from now equates to 2.917 years remaining to maturity.

Figure 26.3: Computing Credit VaR With Credit Spreads

Rating	Spread	Probability	Bond Value ($)	Loss ($)
Default		0.100%	300.00	589.00
BB	400	0.433%	832.19	56.81
BB	350	0.433%	843.69	45.31
BB	300	0.433%	855.41	33.59
BBB	180	32.533%	884.43	4.57
BBB	150	32.533%	891.90	−2.90
BBB	120	32.533%	899.44	−10.44
A	110	0.333%	901.98	−12.98
A	90	0.333%	907.08	−18.08
A	70	0.333%	912.21	−23.21

The output shows that the credit VaR is $589.00 for a confidence level higher than 99.9%. For a confidence level between 99.9% and 99.467%, the credit VaR is $56.81.

For credit VaR calculations, a constant level of risk is often assumed such that risk is brought back to its initial levels through periodic portfolio rebalancing. A *constant level of risk strategy* is where a company holding bonds with a specific rating (like AA) would then sell those bonds if they no longer hold that rating and replace them with AA-rated bonds. A *buy-and-hold strategy* involves holding the original bond for a period of time (say, one year) and then selling.

The buy-and-hold strategy will generally produce larger losses from big downgrades and defaults than the constant level of risk strategy. However, small rating changes naturally produce lower probabilities of losses. Credit VaR tends to be smaller with the constant level of risk strategy.

MODULE QUIZ 26.2

1. Company A has an ROE of 8%, while Company B has an ROE of 6%. The average correlation between the two is 0.24, and both companies are publicly traded. The credit correlation (ρ) most likely used in Vasicek's Gaussian copula model will be closest to:
   A. 0.12.
   B. 0.24.
   C. 0.48.
   D. 0.76.

2. If an analyst wants a credit risk model that accounts for both defaults and downgrades, she will most likely use which of the following models?
   A. CreditMetrics.
   B. Credit Risk Plus.
   C. Vasicek's model.
   D. Monte Carlo simulation.

3. When accounting for credit spreads and potential bond losses for a bond currently rated A, an analyst will likely assign the:
   A. biggest spreads to situations where the bond rating increases.
   B. lowest probability to situations where the bond rating increases.
   C. lowest spreads to situations where the bond maintains its rating.
   D. highest probability to situations where the bond maintains its rating.

KEY CONCEPTS

LO 26.a

Credit risk VaR is defined as the credit risk loss that will not be exceeded over a given period of time within a specific confidence level. Key differences between credit risk VaR and market risk VaR include:

- Market risk VaR is usually calculated with a one-day time horizon. For credit risk VaR, a one-year time horizon is often used.
- While historical simulation is the primary tool for calculating market risk VaR, more elaborate modeling tools are often needed for credit risk VaR calculations.

LO 26.b

Credit VaR models must account for credit correlation, which is a recognition that defaults for different companies are not independent of one another. A strong economy will generally have a positive impact on companies such that default risk is lessened, while a poor economy will have a negative impact on companies such that defaults will be more prominent. As credit correlation increases during economic downturns, financial institution risks increase.

LO 26.c

Rating transition matrices can be used to calculate credit VaR. These matrices are based on historical data and will reflect the likelihood that a company will migrate among rating categories over a given period of time. Naturally, the highest probabilities are associated with a company maintaining its rating by year-end.

To extend the analysis beyond one year, the matrix can be multiplied by itself. For example, a three-year transition matrix is the third power of the one-year matrix. Alternatively, a time period less than one year can also be considered. As the time period extends out further, default probabilities are higher and the odds of maintaining the same credit rating are lower. As time periods shorten, default probabilities are lower and the odds of maintaining the same credit rating are higher.

LO 26.d

Vasicek's Gaussian copula model is a method used on a portfolio of loans to calculate high percentiles of the distribution of the default rate. The formula computes WCDR(T,X), which is the worst-case default rate during time period *T* at the *X*th percentile of the default rate distribution. The model relates the probability of default (PD) to the credit correlation (ρ) and time period *T*.

$$\text{WCDR}(T,X) = N\left(\frac{N^{-1}(PD) + \sqrt{\rho}N^{-1}(X)}{\sqrt{1-\rho}}\right)$$

The *X*th percentile of the loss distribution for an individual loan can be calculated by determining the WCDR for each loan and multiplying it by the exposure at default (EAD) and the loss given default (LGD). For a large portfolio with *n* small loans, the *X*th percentile of the loss distribution can be approximated as:

$$\sum_{i=1}^{n} \text{WCDR}_i(T,X) \times \text{EAD}_i \times \text{LGD}_i$$

The credit correlation (ρ) used in Vasicek's model should be approximately equivalent to the correlation between the two companies returns on assets or returns on equities.

LO 26.e

Credit Suisse developed a credit VaR calculation methodology known as the Credit Risk Plus model. Assuming independent defaults, the binomial distribution can be used to estimate the number of defaults. An outcome of this modeling is that as volatility (σ) decreases, the negative binomial distribution will follow the same probability distribution as the Poisson distribution. As σ increases, the likelihood of experiencing a large number of defaults increases.

Monte Carlo simulation is a way to incorporate default rate uncertainty into the modeling process. A model that ties the default rate in a given year to prior year default rates or economic elements from the prior year is desirable. As default rate uncertainty rises, the probability of large numbers of defaults rises because default correlation increases, and the loss probability distribution has a positive skew (versus being symmetrical with low or no default correlation).

While Vasicek's model and Credit Risk Plus only account for defaults and not downgrades, the CreditMetrics model (from JPMorgan) accounts for both defaults and downgrades. The model uses a rating transition matrix, with ratings either from bank internal ratings or from external credit rating agencies.

Monte Carlo simulation is needed for one-year credit VaR calculations on portfolios of transactions with multiple counterparties. Each trial involves determining counterparty credit ratings at the end of one year, with the credit loss calculated for each counterparty. The term structure of credit spreads for each rating category is needed for these calculations and is assumed to be either the same as what is observable in the market or based on a credit spread index. The model produces a probability distribution for total credit losses from defaults and downgrades across all counterparties.

In the correlation model, credit rating changes for unique counterparties are assumed to be related (not independent). A joint probability distribution of rating changes can be constructed using a Gaussian copula model, with the correlation between rating transitions for two companies equated to the correlation between their equity returns.

LO 26.f

Credit-sensitive products have values that naturally depend on credit spreads. Credit VaR calculations will therefore involve assessing potential credit spread changes. A CreditMetrics approach can be used, where a rating transition matrix is developed over a specific period. Historical data on rating changes provide a probability distribution for credit spread changes over that same time period. Monte Carlo simulation is then used, where each trial samples the matrix to show whether a company keeps the same rating, changes to a different rating, or defaults.

To introduce credit correlation, either a Gaussian copula model can be used for different company rating change correlations or rating category credit spread changes can be assumed to have very high correlations such that spreads for different rated instruments move in unison.

A constant level of risk strategy is where a company holding bonds with a specific rating (like AA) would then sell those bonds if they no longer hold that rating and replace them with AA-rated bonds. A buy-and-hold strategy involves holding the original bond for a period of time (say, one year) and then selling. The buy-and-hold strategy will generally produce larger losses from big downgrades and defaults than the

constant level of risk strategy. Credit VaR tends to be smaller with the constant level of risk strategy.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 26.1

1. **D** Market risk VaR is usually calculated over a one-day time horizon, while credit risk VaR will often use a one-year time horizon. (LO 26.a)

2. **B** When the economy is slowing, companies are negatively impacted, and defaults will become more prominent. At the same time, credit correlation (which captures the lack of independence between defaults for different companies) increases as well. (LO 26.b)

3. **C** If 91.93% is the likelihood that the company keeps its rating over a one-year period, then there is a 71.42% chance it keeps that rating over a four-year period. $0.9193^4 = 0.7142 = 71.42\%$. (LO 26.c)

Module Quiz 26.2

1. **B** The average correlation between company ROEs can be used to determine ρ. Because the average correlation is given as 0.24, that is the most likely correlation used in Vasicek's model. (LO 26.d)

2. **A** The CreditMetrics model is used to account for both defaults and downgrades, whereas Vasicek's model and the Credit Risk Plus model do not. Monte Carlo simulation is an underlying technique applied to various models. (LO 26.e)

3. **D** An analyst will likely assign the highest probability to situations where the bond maintains its rating. The biggest spreads will be for situations where the bond rating decreases, and the lowest spreads will be for situations where the bond rating increases. The lowest probability will likely be for a bond default. (LO 26.f)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Malz, Chapter 8.

READING 27

PORTFOLIO CREDIT RISK

Study Session 5

EXAM FOCUS

In this reading, we discuss the role that default correlation plays in measuring the default risk for a credit portfolio. For the exam, be prepared to list drawbacks of using default correlation and explain the single-factor model approach under the assumption that defaults are independent and returns are normally distributed. Know how to calculate the mean and standard deviation of the default distribution under the single-factor model conditional approach for correlations of 0 and 1 and the unconditional approach for correlations between 0 and 1. Lastly, be able to explain how VaR is determined using the single-factor model and copula methodology based on simulated terminal values.

MODULE 27.1: CREDIT PORTFOLIOS AND CREDIT VaR

Default Correlation for Credit Portfolios

LO 27.a: Define and calculate default correlation for credit portfolios.

Risks to consider when analyzing credit portfolios include default probability, loss given default (LGD), probability of deteriorating credit ratings, spread risk, and risk of loss through restructuring in bankruptcy. **Default correlation** measures the probability of multiple defaults for a credit portfolio issued by multiple obligors.

Suppose there are two firms whose probabilities of default over the next time horizon t are π_1 and π_2 for each firm, respectively. In addition, there is a joint probability that both firms will default over time horizon t equal to π_{12}.

The default correlation for this simple two-firm credit portfolio can be framed around the concept of Bernoulli-distributed random variables x_i, that have four possible outcomes over a specific time horizon t. Figure 27.1 illustrates the four possible random outcomes where 0 denotes the event of no default and 1 denotes default. The

random variables for Firm 1 and 2 are x_1 and x_2. The probabilities of the four random events (Firm 1 defaults, Firm 2 defaults, both firms default, and neither firm defaults) are illustrated in Figure 27.1.

Figure 27.1: Default Probabilities for Two Firms

Event	x_1	x_2	$(x_1\ x_2)$	Default Probability
Firm 1 defaults	1	0	0	$\pi_1 - \pi_{12}$
Firm 2 defaults	0	1	0	$\pi_2 - \pi_{12}$
Both default	1	1	1	π_{12}
No default	0	0	0	$1 - \pi_1 - \pi_2 + \pi_{12}$

Thus, the probability that one of the firms defaults or both firms default equals: $\pi_1 + \pi_2 - \pi_{12}$. Since the probabilities of all four events must equal 1, the probability that no firm defaults is $1 - \pi_1 - \pi_2 + \pi_{12}$. The means of the two Bernoulli-distributed default processes are: $E[x_i] = \pi_i$, where *i* equals 1 or 2. The expected value of joint default is simply the product of the two denoted as: $E[x_1x_2] = \pi_{12}$. The variances are computed as: $E[x_i]^2 - (E[x_i])^2 = \pi_i(1 - \pi_i)$ and the covariance is computed as: $E[x_1x_2] - E[x_1]E[x_2] = \pi_{12} - \pi_1\ \pi_2$.

Equation 1 defines the default correlation for a two-firm credit portfolio as the covariance of Firm 1 and 2 divided by the standard deviations of Firm 1 and 2.

Equation 1

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

EXAMPLE: Calculating default correlation

Assume a portfolio of two credits, one rated BBB+ and one rated BBB, whose probabilities of default over the next time horizon *t* are 0.002 and 0.003, respectively. In addition, assume there is a joint probability that both credits will default over time horizon *t* equal to 0.00015. **Calculate** the default correlation for this credit portfolio.

Answer:

Default correlation can be calculated using the following formula for a two-credit portfolio:

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}} = \frac{0.00015 - (0.002 \times 0.003)}{\sqrt{0.002(1-0.002)}\sqrt{0.003(1-0.003)}}$$

$$= \frac{0.000144}{\sqrt{0.001996}\sqrt{0.002991}} = \frac{0.000144}{(0.04468 \times 0.05469)}$$

$$= 0.0589 \text{ or } 5.89\%$$

Credit Portfolio Framework

LO 27.b: Identify drawbacks in using the correlation-based credit portfolio framework.

A major drawback of using the default correlation-based credit portfolio framework is the number of required calculations. For example, to specify all possible outcome events in a three firm framework requires three individual firm default outcome probabilities, three two-default outcome probabilities, the three-default outcome probability, and the no default outcome probability. Thus, there are 2^n event outcomes with only $(n + 1) + [n(n - 1) / 2]$ conditions. If we have ten firms, there will be 1,024 event outcomes with 56 conditions. The number of pairwise correlations is equal to $n(n - 1)$. In modeling credit risk, the pairwise correlations are often set to a single, nonnegative parameter.

In addition, certain characteristics of credit positions do not fit well in the default correlation credit portfolio model. Guarantees, revolving credit agreements, and other contingent liabilities have features similar to options that are not reflective of this simplistic framework. For example, credit default swap (CDS) basis trades may not be modeled simply by credit or market risk. Rather technical factors may play an important role as was evident in the subprime mortgage crisis where there was a lack of liquidity. Furthermore, convertible bonds have characteristics of credit and equity portfolios driven by market and credit risks.

Additional drawbacks in using the default correlation-based credit portfolio framework are related to the limited data for estimating defaults. Firm defaults are relatively rare events. Therefore, estimated correlations vary greatly depending on the data time horizon and industry. Most studies use an estimated correlation of 0.05. Thus, default correlations are small in magnitude, and the joint probability of two firms defaulting is even smaller.

Credit VaR

LO 27.c: Assess the impact of correlation on a credit portfolio and its Credit VaR.

LO 27.h: Assess the effect of granularity on Credit VaR.

The effects of default, default correlation, and loss given default are important determinants in measuring credit portfolio risk. A portfolio's **credit value at risk** (credit VaR) is defined as the quantile of the credit loss less the expected loss of the portfolio. Default correlation impacts the volatility and extreme quantiles of loss rather than the expected loss. Thus, default correlation affects a portfolio's credit VaR.

If default correlation is 1, then there are no credit diversification benefits, and the portfolio behaves as if there were just one credit position. A default correlation equal to 0 implies the portfolio is a binomial-distributed random variable because there is no correlation with other firms/credits.

EXAMPLE: Computing credit VaR (default correlation = 1, number of credits = n)

Suppose there is a portfolio with a value of $1,000,000 that has *n* credits. Each of the credits has a default probability of π percent and a recovery rate of zero. This implies that in the event of default, the position has no value and is a total loss.

What is the extreme loss given default and credit VaR at the 95% confidence level if π is 2% and the default correlation is equal to 1?

Answer:

With the default correlation equal to 1, the portfolio will act as if there is only one credit. Viewing the portfolio as a binomial-distributed random variable, there are only two possible outcomes for a portfolio acting as one credit. Regardless of whether the number of credits in the portfolio, *n*, is 1, 20, or 1,000, it will still act as one credit when the correlation is 1.

The portfolio has a π percent probability of total loss and a (1 − π) percent probability of zero loss. Therefore, with a recovery rate of zero, the extreme loss given default is $1,000,000. The expected loss is equal to the portfolio value times π and is $20,000 in this example (= 0.02 × $1,000,000). There is a 98% probability that the loss will be 0, given the fact that π equals 2%. The credit VaR is defined as the quantile of the credit loss minus the expected loss of the portfolio. Therefore, at the 95% confidence level, the credit VaR is equal to −$20,000 (= 0 minus the expected loss of $20,000).

Note that if π was greater than (1 − confidence level), the credit VaR would have been calculated as $1,000,000 − $20,000 = $980,000.

EXAMPLE: Computing credit VaR (default correlation = 0, number of credits = 50)

Again suppose there is a $1,000,000 portfolio with *n* credits that each have a default probability of π percent and a zero recovery rate. However, in this example the default correlation is 0, n = 50, and π = 0.02. In addition, each credit is equally weighted and has a terminal value of $20,000 if there is no default. The number of defaults is binomially distributed with parameters of n = 50 and π = 0.02. The 95th percentile of the number of defaults based on this distribution is 3. What is the credit VaR at the 95% confidence level based on these parameters?

Answer:

The expected loss in this case is also $20,000 (= $1,000,000 × 0.02). If there are three defaults, the credit loss is $60,000 (= 3 × $20,000). The credit VaR at the 95% confidence level is $40,000 (calculated by taking the credit loss of $60,000 and subtracting the expected loss of $20,000).

The term "granular" refers to reducing the weight of each credit as a proportion of the total portfolio by increasing the number of credits. As a credit portfolio becomes more

granular, the credit VaR decreases. However, when the default probability is low, the credit VaR is not impacted as much when the portfolio becomes more granular.

EXAMPLE: Computing credit VaR (default correlation = 0, number of credits = 1,000)

Suppose there is a $1,000,000 portfolio with *n* credits that each have a default probability, π, equal to 2% and a zero recovery rate. The default correlation is 0 and n = 1,000. There is a probability of 28 defaults at the 95th percentile based on the binomial distribution with the parameters of n = 1,000 and π = 0.02. What is the credit VaR at the 95% confidence level based on these parameters?

Answer:

The 95th percentile of the credit loss distribution is $28,000 [= 28 × ($1,000,000 / 1,000)] The expected loss in this case is $20,000 (= $1,000,000 × 0.02). The credit VaR is then $8,000 (= $28,000 − expected loss of $20,000).

Thus, as the credit portfolio becomes more granular, the credit VaR decreases. For very large credit portfolios with a large number of independent credit positions, the probability that the credit loss equals the expected loss eventually converges to 100%.

MODULE QUIZ 27.1

1. Which of the following equations best defines the default correlation for a two-firm credit portfolio?

   A. $\rho_{12} = \frac{\pi_{12} - \pi_1 \pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$

   B. $\rho_{12} = \frac{\pi_{12}}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$

   C. $\rho_{12} = \frac{\pi_{12}}{\sqrt{(1-\pi_1)}\sqrt{(1-\pi_2)}}$

   D. $\rho_{12} = \frac{\pi_{12} - \pi_1 \pi_2}{\sqrt{\pi_1}\sqrt{\pi_2}}$

2. Suppose a portfolio manager is using a default correlation framework for measuring credit portfolio risk. How many unique event outcomes are there for a credit portfolio with eight different firms?

   A. 10.
   B. 56.
   C. 256.
   D. 517.

3. Suppose a portfolio has a notional value of $1,000,000 with 20 credit positions. Each of the credits has a default probability of 2% and a recovery rate of zero. Each credit position in the portfolio is an obligation from the same obligor, and therefore, the credit portfolio has a default correlation equal to 1. What is the credit value at risk at the 99% confidence level for this credit portfolio?

   A. $0.
   B. $1,000.

C. $20,000.
D. $980,000.

MODULE 27.2: CONDITIONAL DEFAULT PROBABILITIES AND CREDIT VaR WITH COPULAS

Conditional Default Probabilities

LO 27.d: Describe the use of a single factor model to measure portfolio credit risk, including the impact of correlation.

LO 27.e: Define beta and calculate the asset return correlation of any pair of firms using the single factor model.

The **single-factor model** is used to examine the impact of varying default correlations based on a credit position's beta. Each individual firm or credit, *i*, has a beta correlation, β_i, with the market, *m*. Firm *i*'s individual asset return is defined as:

Equation 2

$$a_i = \beta_i m + \sqrt{1-\beta_i^2}\,\varepsilon_i$$

where:

$\sqrt{1-\beta_i^2}$ = firm's standard deviation of idiosyncratic risk
ε_i = firm's idiosyncratic shock

Assuming that each ε_i is not correlated with other credits, each return on asset, a_i, is a standard normal variate. The correlation between pairs of individual asset returns between two firm's *i* and *j* is $\beta_i\beta_j$. The model assumes that Firm *i* defaults if $a_i \le k_i$, the logarithmic distance to the defaulted asset value that is measured by standard deviations.

An important property of the single-factor model is conditional independence. Conditional independence states that once asset returns for the market are realized, default risks are independent of each other. This is due to the assumption for the single-factor model that return and risk of assets are correlated only with the market factor. The property of conditional independence makes the single-factor model useful in estimating portfolio credit risk.

So, how can the single-factor model be used to measure default probabilities that are conditional on market movements or economic health? Suppose that the market factor, *m*, has a specific value of $\overline{m}$. Substituting this value $\overline{m}$ into Equation 2 and subtracting β_i $\overline{m}$ from both sides results in Equation 3. Default risk is measured by the distance to default, $a_i - \beta_i\overline{m}$. This distance to default either increases or decreases, and the only random parameter is the idiosyncratic shock, ε_i.

Equation 3

$$a_i - \beta_i \overline{m} = \sqrt{1 - \beta_i^2}\,\varepsilon_i$$

As a result of this conditioning, the default distribution's mean shifts based on the specific market value for any beta, β_i, that is greater than zero. The default threshold, k_i, does not change, but the standard deviation of the default distribution is reduced from 1 to $\sqrt{1 - \beta_i^2}$.

The unconditional default distribution is a standard normal distribution. However, the conditional distribution is a normal distribution with a mean of $\beta_i \overline{m}$ and a standard deviation of $\sqrt{1 - \beta_i^2}$. Specifying a specific value $\overline{m}$ for the market parameter, *m*, in the single-factor model results in the following implications:

1. The conditional probability of default will be greater or smaller than the unconditional probability of default as long as $\overline{m}$ or β_i are not equal to zero. This reduces the default triggers or number of idiosyncratic shocks, ε_i, so that it is less than or equal to $k_i - \beta_i \overline{m}$. As the market factor goes from strong to weak economies, a smaller idiosyncratic shock will trigger default.
2. The conditional standard deviation $\sqrt{1 - \beta_i^2}$ is less than the unconditional standard deviation of 1.
3. Individual asset returns, a_i, and idiosyncratic shocks, ε_i, are independent from other firms' shocks and returns.

Conditional Default Distribution Variance

LO 27.f: Using the single factor model, estimate the probability of a joint default of any pair of credits and the default correlation between any pair of credits.

Suppose a firm has a beta, β_i, equal to 0.5 and a default threshold, k_i, equal to −2.33. The unconditional probability of default $\Phi(-2.33) = 0.01$. If the market return is −0.5, what is the conditional variance of the default distribution using the single-factor model?

PROFESSOR'S NOTE
Recall that the symbol Φ represents a standard normal distribution function.

The conditional distribution is a normal distribution with a mean of $\beta_i \overline{m}$ and a conditional variance of $1 - \beta_i^2$. For this example, the mean is $\beta_i \overline{m} = 0.5(-0.5) = -0.25$, and the conditional variance is $1 - 0.5^2 = 0.75$. The conditional standard deviation is then 0.866 (the square root of the variance of 0.75).

The conditional cumulative default probability function is stated as a function of *m* as follows:

$$p(m) = \Phi\left(\frac{k_i - \beta_i \overline{m}}{\sqrt{1 - \beta_i^2}}\right)$$

The mean is the new distance to default based on the realized market factor, $\beta_i\overline{m}$, and the standard deviation assumes conditional independence and is equivalent to $\sqrt{1-\beta_i^2}$. Thus, given a realized market factor, $\overline{m}$, the probability of default is based on the distance of the new default trigger of idiosyncratic shocks, ε_i, measured in standard deviations below its mean of zero.

PROFESSOR'S NOTE
For the exam, focus on how to calculate the parameters of the distribution (e.g., the mean and the standard deviation).

If we assume that distribution parameters (β, k, and π) are equal for all firms, then the probability of a joint default for two firms can be defined as:

$$\Phi\left(\frac{k}{k}\right) = P\left[-\infty \leq a \leq k, -\infty \leq a \leq k\right]$$

This assumption also allows us to define the default correlation for any pair of firms as follows:

Equation 4

$$\rho = \frac{\Phi\left(\frac{k}{k}\right) - \pi^2}{\pi(1-\pi)}$$

Although the derivation of this default correlation equation is not required for the exam, you may wish to understand how Equation 1 (from LO 27.a) is used to derive Equation 4.

The single-factor model assumes the cumulative return distribution of any pair of credit positions i and j is distributed as a bivariate standard normal distribution with a correlation coefficient equal to $\beta_i\beta_j$. The cumulative distribution function for this pair, i and j, is $\Phi\left(\frac{a_i}{a_j}\right)$. We are interested in the probability of a joint default that will occur in the extreme tail of the distributions. Thus, the probability that the realized value for credit i, a_i, is less than the default threshold, or critical value, k_i, and is denoted for the pair of credits i and j as:

$$\Phi\left(\frac{k_i}{k_j}\right) = P\left[-\infty \leq a_i \leq k_i, -\infty \leq a_j \leq k_j\right]$$

In LO 27.a, Equation 1 defined the default correlation as the covariance of Firm 1 and 2 divided by the standard deviations of Firm 1 and 2 as follows:

$$\rho_{ij} = \frac{\pi_{ij} - \pi_i\pi_j}{\sqrt{\pi_i(1-\pi_i)}\sqrt{\pi_j(1-\pi_j)}}$$

Substituting $\Phi\left(\frac{k_i}{k_j}\right)$ for π_{ij} results in:

$$\rho_{ij} = \frac{\Phi\left(\frac{k_i}{k_j}\right) - \pi_i\pi_j}{\sqrt{\pi_i(1-\pi_i)}\sqrt{\pi_j(1-\pi_j)}}$$

If we assume that parameters (β, k, and π) are equal for all firms, then the pairwise asset return correlation for any two firms must equal β^2 and the previous equation simplifies to Equation 4.

Credit VaR With a Single-Factor Model

Previously, the loss distribution was estimated when the default correlation was either 0 or 1. In order to define the distribution of loss severity for values between 0 and 1, we need to determine the unconditional probability of default loss. Using the single-factor model framework, the unconditional probability of a default loss level is equal to the probability that the realized market return results in a default loss. In other words, the individual credit asset returns, a_i, are strictly a function of the market return and the asset return's correlation, or β_i, with the market. The unconditional distribution used to calculate credit VaR is determined by the following steps:

1. The default loss level is assumed to be a random variable X with realized values of x. Under this framework, x is not simulated.
2. Given a loss level of x, the value for the market factor, m, is determined at the probability of the stated loss level. The relationship between the loss level and market factor return is equal to:

$$x(m) = p(m) = \Phi\left(\frac{k - \beta\overline{m}}{\sqrt{1-\beta^2}}\right)$$

   The market factor return, $\overline{m}$, for a given loss level, $\overline{x}$, is determined based on the following relationship:

$$\Phi^{-1}(\overline{x}) = \left(\frac{k - \beta\overline{m}}{\sqrt{1-\beta^2}}\right)$$

3. The market factor is assumed to be standard normal, and therefore, a loss level of 0.01 (99% confidence level) is equal to a value of –2.33 based on the standard normal distribution.
4. These steps are repeated for each individual credit to determine the loss probability distribution.

> **EXAMPLE: Realized market value**
>
> Suppose a credit position has a correlation to the market factor of 0.25. What is the realized market value used to compute the probability of reaching a default threshold at the 99% confidence level?
>
> **Answer:**
>
> At the 99% confidence level, the default loss level has a default probability, π, of 0.01. A default loss level of 0.01 corresponds to –2.33 on the standard normal distribution. The relationship between the default loss level and the given market return, $\overline{m}$, is defined by:

$$p(\overline{m}) = 0.01 = \Phi\left(\frac{k - \beta\overline{m}}{\sqrt{1-\beta^2}}\right)$$

This is approximately equal to the probability of obtaining a realized market return of –2.33 as follows:

$$\Phi^{-1}(0.01) \approx -2.33 = \left(\frac{k - \beta\overline{m}}{\sqrt{1-\beta^2}}\right)$$

The realized market value is computed as follows:

$$-2.33 = \frac{-2.33 - (0.25)\overline{m}}{\sqrt{1-0.25^2}}$$
$$-2.33(0.9682) = -2.33 - (0.25)\overline{m}$$
$$-2.256 + 2.33 = -(0.25)\overline{m}$$
$$0.074 = -(0.25)\overline{m}$$
$$-0.296 = \overline{m}$$

The probability that the default threshold is reached is the same probability that the realized market return is –0.296 or lower.

The parameters play an important role in determining the unconditional loss distribution. The probability of default, π, determines the unconditional expected default value for the credit portfolio. The credit position's correlation to the market, β, determines the dispersion of the defaults based on the range of the market factor.

Credit VaR With Simulation

LO 27.g: Describe how Credit VaR can be calculated using a simulation of joint defaults.

Copulas provide a mathematical approach for determining how defaults are correlated with one another using simulated results. The following four steps are used to compute a credit VaR under the copula methodology:

1. Define the copula function.
2. Simulate default times.
3. Obtain market values and profit and loss data for each scenario using the simulated default times.
4. Compute portfolio distribution statistics by adding the simulated terminal value results.

EXAMPLE: Computing credit VaR with a copula

Suppose there is a credit portfolio with two loans (rated CCC and BB) that each has a notional value of $1,000,000. Figure 27.2 illustrates four possible event outcomes over a default time horizon of one year for this credit portfolio. The four event

outcomes are only the BB rated loan defaults, only the CCC rated loan defaults, both loans default, or no loans default.

Figure 27.2: Event Outcomes for a Two-Credit Portfolio

Event	Default Time
BB default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} > 1)$
CCC default	$(\tau_{BB,i} > 1, \tau_{CCC,i} \leq 1)$
Both default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} \leq 1)$
No default	$(\tau_{BB,i} > 1, \tau_{CCC,i} > 1)$

How can credit VaR be estimated for this portfolio assuming a correlation of 0.25?

Answer:

The copula approach to estimating credit VaR is applied using the following steps:

1. The first step is to simulate 1,000 values using a copula function. The most common copula used to calculate credit VaR is the normal copula.
2. The 2,000 simulated values (1,000 pair simulations results in 2,000 values) are then mapped to their standard univariate normal quantile which results in 1,000 pairs of probability values.
3. The first and second elements of each probability pair are mapped to the BB and CCC default times, respectively.
4. A terminal value is assigned to each loan for each simulation. The values are added up for the two loans, and the sum of the no-default event value is subtracted to determine the loss. Figure 27.3 summarizes the sum of the terminal values and losses for 1,000 simulations.

Figure 27.3: Event Outcomes for a Two-Credit Portfolio

Event	Default Time	Terminal Value	Loss
BB default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} > 1)$	1,480,000	710,000
CCC default	$(\tau_{BB,i} > 1, \tau_{CCC,i} \leq 1)$	1,410,000	780,000
Both default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} \leq 1)$	700,000	1,490,000
No default	$(\tau_{BB,i} > 1, \tau_{CCC,i} > 1)$	2,190,000	0

The loss level sums from the simulation are then used to determine the credit VaR based on the simulated distribution. In this simulation, the 99% confidence level corresponds to the $1,490,000 loss where both loans default. The 95% confidence level corresponds to the $780,000 value because the lower 5% of the simulated values resulted in defaults with a total loss of $780,000.

MODULE QUIZ 27.2

1. A portfolio manager uses the single-factor model to estimate default risk. What is the mean and standard deviation for the conditional distribution when a specific realized market value $\overline{m}$ is used?

A. The mean and standard deviation are equivalent in the standard normal distribution.
B. The mean is $\beta_i \overline{m}$ and the standard deviation is $\sqrt{1-\beta_i^2}$.
C. The mean is $\overline{m}$ and the standard deviation is β_i.
D. The mean is $\overline{m}$ and the standard deviation is 1.

2. Suppose a credit position has a correlation to the market factor of 0.5. What is the realized market value that is used to compute the probability of reaching a default threshold at the 99% confidence level?
A. −0.2500.
B. −0.4356.
C. −0.5825.
D. −0.6243.

KEY CONCEPTS

LO 27.a

The default correlation for a two credit portfolio assuming the outcomes are Bernoulli-distributed random variables is:

$$\rho_{12} = \frac{\pi_{12} - \pi_1 \pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

LO 27.b

Drawbacks of using the default correlation-based credit portfolio framework are the number of required calculations (2^n event outcomes with $(n + 1) + [n(n - 1) / 2]$ conditions), certain characteristics of credit positions do not fit well in the default correlation credit portfolio model, and the limited data for estimating defaults due to the fact that firm defaults are relatively rare events.

LO 27.c

Default correlation affects a portfolio's credit value at risk (credit VaR). A default correlation equal to 0 implies the portfolio is a binomially distributed random variable. As a credit portfolio becomes more granular, the credit VaR decreases.

A portfolio's credit VaR can be defined as the quantile of the credit loss less the expected loss of the portfolio.

LO 27.d

In the single-factor model, Firm *i*'s individual asset return is defined as:

$a_i = \beta_i m + \sqrt{1-\beta_i^2}\varepsilon_i$ where $\sqrt{1-\beta_i^2}$ is the firm's standard deviation of idiosyncratic risk, and ε_i is the firm's idiosyncratic shock. The model assumes that Firm *i* defaults if $a_i \leq k_i$.

The single-factor model framework states that the unconditional probability of a default loss level is equal to the probability that the realized market return results in a default loss. The market factor is assumed to be standard normal. The credit position's

correlation to the market, β, determines the dispersion of the defaults based on the range of the market factor.

LO 27.e

Each individual firm or credit, *i*, has a beta correlation, β_i, with the market, *m*. The correlation between pairs of individual asset returns between two firm's *i* and *j* is $\beta_i\beta_j$.

LO 27.f

If we assume that distribution parameters (β, *k*, and π) are equal for all firms, then the probability of a joint default for two firms can be defined as:

$$\Phi\left(\frac{k}{k}\right) = P\left[-\infty \leq a \leq k, -\infty \leq a \leq k\right]$$

This assumption also allows us to define the default correlation for any pair of firms as follows:

$$\rho = \frac{\Phi\left(\frac{k}{k}\right) - \pi^2}{\pi(1-\pi)}$$

LO 27.g

A credit VaR under the copula methodology is computed by: defining the copula function, simulating default times, obtaining market values and profit and loss data for each scenario using the simulated default times, and computing the portfolio distribution statistics by adding the simulated terminal value results.

LO 27.h

As a credit portfolio becomes more granular, credit VaR decreases. However, when the default probability is low, credit VaR is not impacted as much when the portfolio becomes more granular.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 27.1

1. **A** The default correlation for a two-firm credit portfolio is defined as:

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

(LO 27.a)

2. **C** There are 256 event outcomes for a credit portfolio with eight different firms calculated as: $2^8 = 256$. (LO 27.b)

3. **D** With the default correlation equal to 1, the portfolio will act as if there is only one credit. Viewing the portfolio as a binomial distributed random variable, there are only two possible outcomes for a portfolio acting as one credit. The portfolio has a 2% probability of total loss and a 98% probability of zero loss. Therefore, with a recovery rate of zero, the extreme loss given default is $1,000,000. The

expected loss is equal to the portfolio value times π and is $20,000 in this example (0.02 × $1,000,000). The credit VaR is defined as the quantile of the credit loss less the expected loss of the portfolio. At the 99% confidence level, the credit VaR is equal to $980,000 ($1,000,000 minus the expected loss of $20,000). (LO 27.c)

Module Quiz 27.2

1. **B** The conditional distribution is a normal distribution with a mean of $\beta_i\overline{m}$ and a standard deviation of $\sqrt{1-\beta_i^2}$. (LO 27.d)

2. **D** A default loss level of 0.01 corresponds to −2.33 on the standard normal distribution. The realized market value is computed as follows:

$$-2.33 = \frac{-2.33 - (0.5)\overline{m}}{\sqrt{1-0.5^2}}$$
$$-2.33(0.86603) = -2.33 - (0.5)\overline{m}$$
$$-2.01785 + 2.33 = -(0.5)\overline{m}$$
$$0.31215 = -(0.5)$$
$$-0.62430 = \overline{m}$$

(LO 27.d)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Malz, Chapter 9.

READING 28

STRUCTURED CREDIT RISK

Study Session 5

EXAM FOCUS

In this reading, we discuss common structured products, capital structure in securitization, structured product participants, a basic waterfall structure, and the impact of correlation. For the exam, understand the qualitative impacts of changing default probability and default correlation for all tranches for mean (average) and risk (credit VaR). Default sensitivity (similar to DV01) is introduced. Understand the process to compute implied correlation extracted from observable market prices.

MODULE 28.1: STRUCTURED PRODUCTS

Types of Structured Products

LO 28.a: Describe common types of structured products.

Securitization and structured products are two of the most important financial innovations in recent memory. Securitization is basically the pooling of credit-sensitive assets and the associated creation of new securities (structured products or portfolio credit products) whose cash flows are based on underlying loans or credit claims. Each product has its own risk and return characteristics, which can vary dramatically from the original assets. For this section, a partial list of structured products and factors that affect their valuation are discussed.

Covered Bonds

Covered bonds are on-balance sheet securitizations. A pool of mortgages, which secure a bond issue, is separated from other loans into a covered pool on the originator's balance sheet. Investors have higher priority than general creditors if a bank defaults. Principal and interest is paid and guaranteed by the originator and is not based on the performance of the underlying assets themselves. Thus, covered bonds are not true securitizations since the assets are not part of a bankruptcy-remote structure and the investors have recourse against the originator.

Mortgage Pass-Through Securities

In contrast to covered bonds, mortgage pass-through securities are true off-balance sheet securitizations. Investors receive cash flows based entirely on the performance of the pool less associated fees paid to the servicer. Most pass-throughs are agency mortgage-backed securities (MBSs) that carry implicit or explicit government guarantee of performance. Thus, default risk is not a serious concern. The primary risk is due to prepayment of principal by the homeowner, most likely from refinancing after interest rate declines or home sales.

Collateralized Mortgage Obligations (CMOs)

CMOs are MBSs that tranche (i.e., divide) cash flows into different securities based on predetermined conditions. The resulting tranches can have long or short maturities, fixed or floating cash flows, or other varieties and conditions. The most basic structure is the *waterfall* or *sequential pay structure* where Tranche 1 receives all principal and its portion of interest in each period until it is paid off. The remaining tranches will receive interest only until Tranche 1 is retired and then principal will flow down to Tranche 2, and so on. Not surprisingly, Tranche 1 will have a very low prepayment risk as it expects to receive all principal payments before other bondholders.

Structured Credit Products

Like other structured products, this pool of assets is backed by risky debt instruments. The difference is that structured credit products create tranches that have different amounts of credit risk. The most junior (i.e., equity) tranches bear the first losses and are most likely to be written down from defaulted assets. If the equity tranche is completely wiped out, the next most junior tranche will bear the credit risk of subsequent defaults. The most senior tranche will have the highest credit rating and the lowest probability of write-downs.

Asset-Backed Securities

This is the most general class of securitizations where cash-flow generating assets are pooled and subsequently tranched. Under this definition, MBS is a special case of the more general ABS. Other varieties include collateralized bond obligations (CBOs), collateralized debt obligations (CDOs), collateralized loan obligations (CLOs), and collateralized mortgage obligations (CMOs). There exist even more complex securities that pool other securitizations together such as CDO-squared (CDO of CDOs).

Structured credit products can also vary across other dimensions. First, the underlying collateral of the pool can consist of loans, bonds, credit card receivables, auto loans, and even non-debt instruments that generate cash flows, such as toll collections. Second, the size and number of tranches is specific to each transaction. Third, the pool can be passive or actively managed. In a passive pool, the existing assets, such as mortgages and auto loans, will eventually pay themselves down. On the other hand, actively managed pools will selectively add or shed assets from the pool. Managers with key insight should be able to enhance the performance of the pool by identifying overvalued and undervalued loan products. Revolving pools have a period of time

where loan proceeds are reinvested in new assets. Once the revolving period ends, the asset balances are fixed (e.g., credit card balances) and will spend themselves down.

Capital Structure in Securitization

LO 28.b: Describe tranching and the distribution of credit losses in a securitization.

The capital structure of a securitization refers to the priority assigned to the different tranches. In general, the most **senior tranches** at the top of the capital structure will have the highest priority to receive principal and interest. Since these securities are perceived to be the safest, they also receive the lowest coupon.

The **equity tranche** is the slice of the cash flow distribution with the lowest priority and will absorb the first losses up to a prespecified level. These securities typically do not carry a fixed coupon but receive the residual cash flows only after the other security claims are satisfied. Therefore, the return is variable and, hence, the term "equity." Typically, the equity tranche is the smallest part of the capital structure.

Between the senior and equity tranches is the **mezzanine tranche** (i.e., the junior tranche). The mezzanine tranches will absorb losses only after the equity tranche is completely written down. Thus, the senior tranches are protected by both the equity and mezzanine debt (termed subordination or credit enhancement). Terminology-wise, the mezzanine debt attaches to the equity tranche from above and detaches from the senior tranche from below. These junior debt claims offer a relatively high coupon (if the claim is fixed) or high spread (if the claim is floating). To keep the securitization viable, the mezzanine tranches will be purposefully thin.

There are many creative ways to provide credit protection to various security classes, but this must come at the expense of shifting risk to other parts of the capital structure. In general, credit enhancement can be divided into internal and external credit enhancement mechanisms. The term **external credit enhancement** means that the credit protection takes the form of insurance or wraps purchased from a third party, typically a monoline insurer.

Two examples of **internal credit enhancements** are overcollateralization and excess spread. **Overcollateralization** is when the pool offers claims for less than the amount of the collateral. For example, consider a collateralized MBS with 101 mortgages in the collateral pool, but the face value of the bonds across all tranches only totals 100 mortgages. Overcollateralization is a *hard credit enhancement* because the protection is available at the origination of the pool.

The **excess spread** is the difference between the cash flows collected and the payments made to all bondholders. For example, if the weighted average of the collateral is 8% (net of fees) and the weighted average of the payments promised to the senior, junior, and equity tranches is 7%, then the residual 1% accumulates in a separate trust account. The excess spread will be invested and is available to make up future shortfalls. Since the excess spread is zero at origination, it is considered a *soft credit enhancement*.

Waterfall Structure

LO 28.c: Describe a waterfall structure in a securitization.

A waterfall structure outlines the rules and conditions that govern the distribution of collateral cash flows to different tranches. In the simplest example of a securitization, the senior and junior bonds will receive their promised coupons conditional on a sufficient amount of cash inflows from the underlying loans. The residual cash flow, if any, is called the excess spread. The overcollateralization triggers will decide how the excess is divided between the equity investors and the accumulating trust. Intuitively, the underlying cash flows will be largest in the earlier periods so the trust will build up a reserve against future shortfalls.

In practice, this process can be quite complex as there may be a dozen tranches or more with different coupons, maturities, and overcollateralization triggers. The waterfall is further complicated by loan defaults. A simplifying assumption would incorporate a constant default rate which can be built into the waterfall distribution. As the loans mature, the actual incidence of the loan defaults will increase or decrease the value of the respective tranches. For example, suppose that fewer loans default than previously assumed, then collateral cash flows are larger than expected and will benefit all bondholders, in particular, the equity tranche.

Let's analyze the cash flows in a waterfall structure by considering the following examples. Assume there are 1,000 identical loans with a value of $1 million each. The interest rate on the loans is floating with a rate equal to the market reference rate + 300 bps, reset annually. The senior, junior, and equity tranches are 80%, 15%, and 5% of the pool, respectively. The spreads on the senior and mezzanine tranches are 1% and 5%. There is one overcollateralization trigger where the equity holders are entitled to a maximum of $15 million and any excess is diverted to the excess trust account. To begin, assume the default rate is 0%. The cash flows for the waterfall structure are detailed in Figure 28.1.

Note that the senior tranche has a principal value of $800 million while the junior tranche has an initial principal of $150 million. Using a current market reference rate of 5%, their respective coupons are 6% (= 5% + 1% spread) and 10% (= 5% + 5% spread). The total cash flows flowing into the pool are $1 billion × 8% = $80 million, which is sufficient to pay the senior and junior claims. The residual cash flow is $80 million − ($48 million + $15 million) = $17 million.

Next, the overcollateralization test must be applied. Since the maximum the equity tranche can receive is $15 million, the equity investors will receive the full $15 million and the excess of $2 million will flow into the trust account. This is shown in the last row of Figure 28.1.

Now assume that the expected default rate is 4% each year. The first difference from the 0% default rate example is that the total loan proceeds is reduced by defaulted loans: $1 billion × 8% × (1 − 0.04) = $76.8 million. There is still sufficient cash flow to pay the senior and junior bondholders in full. However, when the overcollateralization

test is applied, the equity holders will not reached their maximum. Therefore, the equity tranche receives only $13.8 million and there is no diversion to the trust account as shown in Figure 28.2.

Figure 28.1: Waterfall Structure (Default Rate = 0%)

Loan Information	
# loans	1,000
Value of identical loan	$1,000,000
Principal amount	$1,000,000,000
Reference rate	5.00%
Spread	3.00%
Coupon	8.00%
Default rate	0.00%
OC trigger	$15,000,000

Tranche Information		
Senior % of pool		80%
	Reference rate	5.00%
	Spread	1.00%
	Coupon	6.00%
Mezzanine % of pool		15%
	Reference rate	5.00%
	Spread	5.00%
	Coupon	10.00%
Equity % of pool		5%

Period	Loan Proceeds	
1	$80,000,000	
Senior Principal	**Senior Coupon**	**Interest**
$800,000,000	6.00%	$48,000,000
Mezzanine Principal	**Mezzanine Coupon**	**Interest**
$150,000,000	10.00%	$15,000,000
Excess CF	**CF to Equity**	**CF to Trust**
$17,000,000	$15,000,000	$2,000,000

Figure 28.2: Waterfall Structure (Default Rate = 4%)

Loan Information	
# loans	1,000
Value of identical loan	$1,000,000
Principal amount	$1,000,000,000
Reference rate	5.00%
Spread	3.00%
Coupon	8.00%
Default rate	4.00%
OC trigger	$15,000,000

Tranche Information		
Senior % of pool		80%
	Reference rate	5.00%
	Spread	1.00%
	Coupon	6.00%
Mezzanine % of pool		15%
	Reference rate	5.00%
	Spread	5.00%
	Coupon	10.00%
Equity % of pool		5%

Period	Loan Proceeds	
1	$76,800,000	
Senior Principal	**Senior Coupon**	**Interest**
$800,000,000	6.00%	$48,000,000
Mezzanine Principal	**Mezzanine Coupon**	**Interest**
$150,000,000	10.00%	$15,000,000
Excess CF	**CF to Equity**	**CF to Trust**
$13,800,000	$13,800,000	$0

MODULE QUIZ 28.1

1. How many of the following statements concerning the capital structure in a securitization are most likely correct?

   I. The mezzanine tranche is typically the smallest tranche size.
   II. The mezzanine and equity tranches typically offer fixed coupons.
   III. The senior tranche typically receives the lowest coupon.

   A. No statements are correct.
   B. One statement is correct.
   C. Two statements are correct.
   D. Three statements are correct.

2. Assume there are 100 identical loans with a principal balance of $500,000 each. Based on a credit analysis, a 300 basis point spread is applied to the borrowers. The market reference rate is currently 4% and the coupon rate will reset annually. The senior,

junior, and equity tranches are 75%, 20%, and 5% of the pool, respectively. The spreads on the senior and mezzanine tranches are 2% and 6%. Excess cash flow is diverted above $1,000,000. Assume the default rate is 2%. What are the cash flows to the mezzanine and excess trust account in the first period?

	Mezzanine	Trust account
A.	$1,000,000	$0
B.	$1,000,000	$180,000
C.	$2,250,000	$200,000
D.	$2,250,000	$250,000

MODULE 28.2: SECURITIZATION

Securitization Participants

LO 28.d: Identify the key participants in the securitization process and describe conflicts of interest that can arise in the process.

The nature of the securitization process from original loan to tranche issuance necessarily involves many different participants. The first step begins with the **originator** who funds the loan. The originator may be a bank, mortgage lender, or other financial intermediary. The term "sponsor" may be used if the originator supplies most of the collateral for the issue.

The **underwriter** performs a function similar to the issuance of traditional debt and equity. The underwriter structures the issue (i.e., engineers the tranche size, coupon, and triggers, and sells the bonds to investors). The underwriter warehouses the collateral and faces the risks that the issue will not be marketed or that the collateral value will drop.

The **credit rating agencies (CRAs)** are an important part of the securitization process. Without their explicit approval via credit ratings, investors would be at a severe disadvantage to assess the riskiness of the issue. The credit rating agencies can influence the size of the tranches by selecting the attachment points and thus are active participants in the process. In addition, the CRAs may influence the issue by requiring enhancements. There is a natural conflict of interest because the CRAs want to generate profit and grow their business, but it may come at the expense of allocating larger portions of the capital structure to lower interest paying senior notes. Investors can alleviate this concern by performing their own (costly) analysis or purchasing a wrap or insurance against the issue.

The role of the servicer is multifaceted and possibly understated. The servicer must collect and distribute the collateral cash flows and the associated fees. In addition, the servicer may need to provide liquidity if payments are late and resolve default situations. It is not hard to envision the conflict of interest in foreclosure: the servicer would, all else equal, like to delay foreclosure to increase their fees, while investors want as quick of a resolution as possible to minimize the damage and/or lack of maintenance from the homeowners who have no economic incentive to maintain the property.

When the pool is actively managed, another source of conflict arises. The manager naturally would like to minimize their effort to continually monitor the credit quality of the collateral unless there is a clear incentive to do so. A common feature of securitized pools is for the originator and/or manager to bear the first loss in the capital structure.

Custodians and trustees play an administrative role verifying documents, disbursing funds, and transferring funds between accounts.

Three-Tiered Securitization Structure

LO 28.e: Compute and evaluate one or two iterations of interim cashflows in a three-tiered securitization structure.

LO 28.f: Describe the treatment of excess spread in a securitization structure and estimate the value of the overcollateralization account at the end of each year.

LO 28.g: Explain the tests on the excess spread that a custodian must go through at the end of each year to determine the cash flow to the overcollateralization account and to the equity noteholders.

The cash flows in a three-tiered securitization (senior, mezzanine, and equity) can be broken out into the inflows from the collateral and the outflows to the investors. The inflows prior to maturity are the interest on the collateral (L_t) plus the recovery from the sale of any defaulted assets in the current period (R_t). Assume the collateral pool has N identical loans with coupons = market reference rate + spread. The terminal cash flows in the final year are the last interest payment plus principal and recovery of defaulted assets. As an additional consideration, the recovered funds from defaults would earn interest over the remaining life of the pool at r.

The outflows are the coupon payments paid to senior and mezzanine note holders, collectively denoted B (assumed constant). The equity holder position is a bit more complicated because the excess spread trust has first priority on the cash flows to provide soft credit enhancement to the more senior tranches. Specifically, the equity holders' cash flows are dependent on the amount of inflows to the pool less any funds diverted to the excess spread account. Denote the amount diverted to the spread trust in year t as (OC_t) with maximum allowable diversion K. To determine the cash flow to equity, the following steps must be performed:

1. Is the current period interest sufficient to cover the promised coupons: $L_t - B \geq 0$? If *yes*, then the following overcollateralization test must be performed to see how much flows to trust: Is $L_t - B \geq K$? If *yes*, then K is diverted to trust, and $L_t - B - K$ flows to equity holders: $OC_t = K$. If *no*, then $L_t - B$ is diverted to trust, and nothing flows to equity holders: $OC_t = L_t - B$.
2. Is the current period interest sufficient to cover the promised coupons: $L_t - B \geq 0$? If *no*, then the interest is not sufficient to pay bondholders and all L_t flows to

bondholders. Therefore, the shortfall is $B - L_t$. The next step is to check if the accumulated funds in the spread trust can cover the shortfall. If the trust account has enough funds, the bondholders can be paid in full. If the trust account does not have enough funds, then the bondholders suffer a write-down.

The previous steps outlined the basic procedure for tranche cash flow distribution; however, a few more factors need to be considered. First, for each period there are possible defaults. For simplicity, assume the number of defaults (d_t) is constant for each period. Second, the amount recovered in year t (assuming a 40% recovery rate) equals:

$$R_t = 0.4d_t \times \text{loan amount}$$

Therefore, the total amount deposited into the trust account in year t is:

$$R_t + OC_t$$

It follows that the total amount accumulated in the trust account in year t is:

$$R_t + OC_t + \sum_{\tau=1}^{t-1} (1+r)^{t-\tau} OC_\tau$$

Now, if excess spread is negative ($L_t - B < 0$), the custodian must check if the trust account can cover the shortfall. Formally, the test for the custodian is:

$$R_t + \sum_{\tau=1}^{t-1} (1+r)^{t-\tau} OC_\tau > B - L_t$$

Note that there is no OC_t term to add to R_t since there is no excess spread this period. If the test is true, then the trust account can make the bondholders whole.

If it is not true, then the fund is reduced to zero and bondholders receive $R_t + \sum_{\tau=1}^{t-1} (1+r)^{t-\tau} OC_\tau$ from the trust account.

Using the previous exposition, the amount diverted to the overcollateralization account can be calculated as:

$$OC_t = \left\{ \begin{matrix} \min(L_t - B, K) \\ \max\left[L_t - B, - \left[\sum_{\tau=1}^{t-1} (1+r)^{t-\tau} OC_\tau + R_t \right] \right] \end{matrix} \right\} \text{for} \left\{ \begin{matrix} L_t \geq B \\ L_t < B \end{matrix} \right\}$$

Note that the upper condition represents inflows to the trust account while the lower condition represents outflows from the trust account.

Finally, the equity cash flows can be expressed as:

$$\max(L_t - B - OC_t, 0) \text{ for } t = 1, \ldots, T-1$$

The cash flows in the final year must be examined separately for several reasons. First, the surviving loans reach maturity and principal is returned. Second, there is no diversion to the trust account because the structure ends and all proceeds follow the waterfall. Third, since there is no diversion to the trust, there is no need to test overcollateralization triggers.

The terminal cash flows are summarized as follows:

1. Loan interest $= \left(N - \sum_{t=1}^{T} d_t\right) \times (\text{reference rate} + \text{spread}) \times \text{par}$
2. Proceeds (par) from redemption of surviving loans $= \left(N - \sum_{t=1}^{T} d_t\right) \times \text{par}$
3. Recovery in final year: $R_T = 0.4d_T \times \text{par}$
4. Residual in trust account: $\sum_{t=1}^{T} (1 + r)^{t-\tau} OC_t$

The sum of these terminal cash flows is compared to the amount due to the senior tranche. If the sum is large enough, the senior tranche is paid off and the remainder is available for the rest of the capital structure. If the remainder is large enough to cover the junior tranche, then the residual flows to equity. If the remainder cannot meet junior claims, the junior bonds receive the excess and equity holders receive nothing.

As an example, determine the terminal cash flows to senior, junior, and equity tranches given the following information. The original loan pool included 100 loans with $1 million par value and a fixed coupon of 8%. The number of surviving loans is 90. The par for the senior and junior tranches is 75% and 20%, respectively. The equity investors contributed the remaining 5%. There were two defaults with recovery rate of 40% recovered at the end of the period. The value of the trust account at the beginning of the period is $16 million earning 4% per annum.

1. Total size of collateral pool at origination: 100 × $1,000,000 = $100,000,000
2. Senior tranche = $75,000,000
   Junior tranche = $20,000,000
   Equity tranche = $5,000,000
3. Interest from loans: 90 × 8% × $1,000,000 = $7,200,000
4. Redemption at par: 90 × $1,000,000 = $90,000,000
5. Recovery in final year: 2 × 40% × $1,000,000 = $800,000
6. Value of OC at end of final year: $16,000,000 × 1.04 = $16,640,000
7. Total available to satisfy all claims = $114,640,000
8. Senior claim = $75,000,000 < $114,640,000. Senior claim is satisfied without impairment
9. Junior claim = $20,000,000 < $114,640,000 − $75,000,000 so junior claim is satisfied
10. Equity claim = $114,640,000 − $75,000,000 − $20,000,000 = $19,640,000

Now, continue with the same example, but change the interest rate to 5% and the beginning OC value to $3 million. The first two steps will be the same as before.

3. Interest from loans: 90 × 5% × $1,000,000 = $4,500,000
4. Redemption at par: 90 × $1,000,000 = $90,000,000
5. Recovery in final year: 2 × 40% × $1,000,000 = $800,000
6. Value of OC at end of final year: $3,000,000. × 1.04 = $3,120,000
7. Total available to satisfy all claims = $98,420,000
8. Senior claim = $75,000,000 < $98,420,000. Senior claim is satisfied without impairment
9. Junior claim = $20,000,000 < $98,420,000 – $75,000,000 so junior claim is satisfied
10. Equity claim = $98,420,000 – $75,000,000 – $20,000,000 = $3,420,000

Finally, continue with the same example, but change the interest rate to 4% and the beginning OC value to $1 million. Assume a recovery rate of zero. Again, the first two steps are the same as before.

3. Interest from loans: 90 × 4% × $1,000,000 = $3,600,000
4. Redemption at par: 90 × $1,000,000 = $90,000,000
5. Recovery in final year: 2 × 0% × $1,000,000 = 0
6. Value of OC at end of final year: $1,000,000 × 1.04 = $1,040,000
7. Total available to satisfy all claims = $94,640,000
8. Senior claim = $75,000,000 < $94,640,000. Senior claim is satisfied without impairment
9. Junior claim = $20,000,000 > $94,640,000 – $75,000,000 so junior claim is impaired
   Junior tranche receives $19,640,000
10. Equity claim = $94,640,000 – $75,000,000 – $20,000,000 < 0
    Equity tranche receives $0

MODULE QUIZ 28.2

1. Which of the following participants in the securitization process is least likely to face a conflict of interest?
   A. Credit rating agency and servicer.
   B. Servicer and underwriter.
   C. Custodian and trustee.
   D. Trustee and manager.

MODULE 28.3: SIMULATION, PROBABILITY OF DEFAULT, AND DEFAULT CORRELATION; DEFAULT

SENSITIVITIES; AND STRUCTURED PRODUCTS

Simulation Approach

LO 28.h: Describe a simulation approach to calculating credit losses for different tranches in a securitization.

The prior analysis made a few very important simplifying assumptions. In particular, the analysis assumed that the default rate was constant year over year, each loan exhibited the same default probability, and the correlation between loans was ignored. In practice, these assumptions need to be brought into the analysis and the only tractable way to do so is via simulation.

Although the technical details are well beyond the scope of the exam, we can identify the basic steps and intuition for the simulation approach to calculating credit losses.

Step 1: Estimate the parameters.

Step 2: Generate default time simulations.

Step 3: Compute portfolio credit losses.

The first step is to estimate the critical parameters, default intensity, and pairwise correlations. The default intensity can be estimated using market spread data to infer the hazard rate across various maturities. Estimating the correlation coefficients is more challenging because of a lack of usable market data. The copula correlation could be useful in theory but suffers empirical precision in practice. Instead, a sensitivity analysis is performed for various default and correlation pairs.

The second step identifies if and when the security defaults. Simulation provides information on the timing for each hypothetical outcome. The third step uses the simulation output to determine the frequency and timing of credit losses. The credit losses can be "lined up" to assess the impact on the capital structure losses. The tail of the distribution will identify the credit VaR for each tranche in the securitization.

Impact of Probability of Default and Default Correlation

LO 28.i: Explain how the default probabilities and default correlations affect the credit risk in a securitization.

There are several important comparative statistics associated with a generic securitization. The following results represent the effect of the average tranche values and write-downs. The implications of extreme tail events will be discussed shortly using VaR. The first factor to consider is the probability of default. It is straightforward to see that, for a given correlation, increasing the probability of default will negatively impact the cash flows and, thus, the values of all tranches.

The effect of changing the correlation is more subtle. Consider the stylized case where the correlation is very low, say zero, so loan performance is independent. Therefore, in a large portfolio, it is virtually impossible for none of the loans to default and it is equally unlikely that there will be a large number of defaults. Rather, the number of defaults should be very close to the probability of default times the number of loans. So, the pool would experience a level of defaults very close to its mathematical expectation and is unlikely to impair the senior tranches. The analogous situation is flipping a coin 1,000 times—the number of heads would be very close to 500. It would be virtually impossible for the number of heads to be less than 400 or greater than 600. Now, if the correlation increases, the default of one credit increases the likelihood of another default. Thus, increasing correlation decreases the value of senior tranches as the pool is now more likely to suffer extreme losses. This effect is exacerbated with a higher default probability.

Now consider the equity tranche. Recall that the equity tranche suffers the first write-downs in the pool. Therefore, a low correlation implies a predictable, but positive, number of defaults. In turn, the equity tranche will assuredly suffer write-downs. On the other hand, if the correlation increases, the behavior of the pool is more extreme, and there may be high levels of related losses or there may be very few loan losses. In sum, the equity tranche increases in value from increasing correlation as the possibility of zero (or few) credit losses increases from the high correlation.

The correlation effect on the mezzanine tranche is more complex. When default rates are low, increasing the correlation increases the likelihood of losses to the junior bonds (similar to senior bonds). However, when default rates are relatively high, increasing the correlation actually decreases the expected losses to mezzanine bonds as the possibility of few defaults is now more likely. Accordingly, the mezzanine bond mimics the return pattern of the equity tranche. In short, increasing correlation at low default rates decreases mezzanine bond values, but at high default rates it will increase mezzanine bond values.

Convexity is also an issue for default rates. For equity investors, as default rates increase from low levels, the equity tranche values decrease rapidly then moderately (a characteristic of positive convexity). Since the equity tranche is thin, small changes in default rates will disproportionately impact bond prices at first. Similarly, senior tranches exhibit negative convexity. As defaults increase, the decline in bond prices increases. As usual, the mezzanine impact is somewhere in between: negative convexity at low default rates, positive convexity at high default rates.

The previous section focused on the average (mean) value of the tranches while this section examines the distribution of possible tranche values (risk). Specifically, the goal is to analyze the impact of default probability and default correlation under extreme conditions (far into the tail). The metric used is credit VaR for various ranges of default probability and default correlation for the senior, junior, and equity tranches. The main result is that increasing default probability, while holding correlation constant, generally decreases the VaR for the equity tranches (less variation in returns) and increases the VaR for the senior tranches (more variation in returns). As usual, the mezzanine effect is mixed: VaR increases at low correlation levels (like senior bonds)

then decreases at high correlation levels (like equity). These results are summarized in Figure 28.3.

Figure 28.3: Increasing Default Probability (Correlation Constant)

	Mean Value	Credit VaR
Equity tranche	↓	↓
Mezzanine tranche	↓	↑ then ↓
Senior tranche	↓	↑

The next effect to consider is the impact of a rising correlation. As a reminder, increasing correlation increases the clustering of events, either high frequency of defaults or very low frequency of defaults. Increasing correlation decreases senior bond prices as the subordination is more likely to be breached if defaults do indeed cluster. In contrast, equity returns increase as the low default scenario is more probable relative to low correlation where defaults are almost certain.

As the default correlation approaches one, the equity VaR increases steadily. The interpretation is that although the mean return is increasing so is the risk as the returns are more variable (large losses or very small losses).

All else equal, the senior VaR also increases consistently with correlation. However, we note an interesting effect: the incremental difference between high correlations (0.6 versus 0.9) is relatively small. In addition, two pairwise results are worth highlighting. If correlation is low and default frequency is relatively high, then senior bonds are well insulated. In fact, at the 10% subordination level, the senior bonds would be unaffected even at a high default rate. At the other extreme, when correlations are high (0.6 or above), then the VaRs are quite similar regardless of the default probability. Hence, generally speaking, correlation is a more important risk factor than default probability which may not be entirely intuitive.

The implications for the mezzanine tranche are, again, mixed. When default rates and correlations are lower, the mezzanine tranche behaves more like senior notes with low VaRs. However, when the default probabilities are higher and/or pairwise correlation is high, the risk profile more closely resembles the equity tranche. These results are summarized in Figure 28.4.

Figure 28.4: Increasing Correlations (Default Probability Constant)

	Mean Value	Credit VaR
Equity tranche	↑	↑
Mezzanine tranche	↓(at low default rates) ↑(at high default rates)	↑
Senior tranche	↓	↑

Measuring Default Sensitivities

LO 28.j: Explain how default sensitivities for tranches are measured.

The previous discussion highlighted the effect of increasing the probability of default, which decreases tranche values. However, this effect is not necessarily linear and also depends on the interaction with the default correlation. To analyze the marginal effects in more detail, the definition of DV01 is extended to default probabilities and is called "default '01." The default probability will be shocked up and down by the same amount (by convention 10 basis points) and each tranche will be revalued through the VaR simulations. The formulation for default '01 of each tranche is as follows:

$$1/20\ [(\text{mean value / loss based on } \pi + 0.001) - (\text{mean value / loss based on } \pi - 0.001)]$$

From this equation, there are several qualitative impacts to note. First, the default sensitivities are always positive for any default probability-correlation combination. This follows from the previous observation that all tranches are negatively affected from increasing default probabilities. Second, the default '01 will approach zero as default rates become sufficiently high as the marginal impact of increasing the default rate has minimal effect. The third result follows from the second. There will be more variation in the default sensitivities when the default rate generates losses close to the tranche's attachment point. This result is similar to the high gamma (high sensitivity in delta) for options at-the-money.

Risks for Structured Products

LO 28.k: Describe risk factors that impact structured products.

Aside from the credit portfolio modeling issues discussed before, there are at least three other risks that deserve discussion: systematic risk, tranche thinness, and loan granularity.

Similar to a well-diversified equity portfolio that cannot eliminate systematic risk, the same holds true for credit portfolios. Unfortunately, even when the collateral pool is well-diversified among lenders, terms, geography, and other factors, high systematic risk expressed in high correlations can still severely damage a portfolio. As previously discussed, with increases in pairwise correlations, the likelihood of senior tranche write-downs increases as well.

The equity and mezzanine tranches are relatively thin. This also manifests itself in the relative closeness of the 95% and 99% credit VaR. The implication is that given that the tranche has been breached, the loss is likely very large.

Loan granularity references the loan level diversification. For example, in a collateralized MBS pool, the portfolio composition is a few loans but the loans are of substantial size. This reduction in sample size increases the probability of tail events in relation to an equal sized portfolio constructed with more loans of smaller amounts.

Implied Correlation

LO 28.l: Define implied correlation and describe how it can be measured.

The implied correlation is a very similar concept to the implied volatility of an equity option. For options, the Black-Scholes-Merton model is a widely accepted valuation model and so the observable market price is associated with a unique unobserved volatility. For securitized tranches, the process is exactly the same. Starting with observed market prices and a pricing function for the tranches, it is possible to back out the unique implied correlation to calibrate the model price with the market price.

The mechanical part of the process involves several intermediate steps. First, the observable credit default swap (CDS) term structure is used to extract risk-neutral default probabilities and possibly recovery rates. Assuming constant pairwise correlation and market prices for the respective tranches, the default estimates and correlation estimates can be fed into a copula. The output is the risk-neutral implied correlation (i.e., base correlation) per tranche. The correlation estimates will vary between the tranches and are not likely to be constant giving rise to correlation skew. As an example, suppose the observed market price of the equity tranche increases from $3 million to $3.2 million, but the estimates of the risk-neutral probability of default remain the same. It can be inferred that the market's estimate of the implied correlation must have increased. The precise value must be extracted from the pricing model but qualitatively the direction is correct; increasing correlations benefit equity holders.

Motivations for Using Structured Products

LO 28.m: Identify the motivations for using structured credit products.

Identifying the motivations of loan originators and investors can provide a better understanding for why securitizations are established.

Loan originators, who help create securitizations by selling loans into a trust, are attracted to borrowing via securitization given its ability to provide a lower cost of funding. Without securitization, loans would either be retained or sold in the secondary market. These alternatives would likely be more costly than securing funding via securitization. A lower cost of funding can be obtained given the diversification of the loan pool and the reputation of the originator for underwriting high-quality loans. However, some loan pools, such as commercial mortgage pools, can be difficult to diversify. Thus, an element of systematic risk may still exist, which could lead to an underestimation of overall risk. An additional benefit of securitization for loan originators is the collection of servicing fees.

Investors, who purchase the assets in a securitization, are attracted to investing in diversified loan pools that they would not otherwise have access to without securitization, such as mortgage loans and auto loans. In addition, the ability to select a desired risk-return level via tranching offers another advantage for investors. Equity

tranches will offer higher risk-return levels, while senior tranches will offer lower risk-return levels. However, it is important for investors to conduct the proper due diligence when analyzing potential tranche investments in order to understand the actual level of risk involved.

MODULE QUIZ 28.3

1. Which of the following statements about portfolio losses and default correlation are most likely correct?

   I. Increasing default correlation decreases senior tranche values but increases equity tranche values.

   II. At high default rates, increasing default correlation decreases mezzanine bond prices.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

2. Which of the following statements best describes the calculation of implied correlation?

   A. The implied correlation for the mezzanine tranche assumes non-constant pairwise correlation.
   B. Observable market prices of credit default swaps are used to infer the tranche values.
   C. The tranche pricing function is calibrated to match the model price with the market price.
   D. The risk-adjusted default probabilities are used in model calibration.

KEY CONCEPTS

LO 28.a

Securitization is the process of pooling cash flow generating assets and reapportioning the cash flows into bonds. These structured products generate a wide range of risk-return profiles that vary in maturity, credit subordination (equity, mezzanine, and senior), type of collateral (mortgages, auto loans, and credit card balances), active or passive management, and static or revolving assets. A true securitization removes the assets from the originator's balance sheet.

LO 28.b

The capital structure of a securitization refers to the different size and priority of the tranches. In general, the senior tranches are the largest, safest, and lowest yielding bonds in the capital structure. The mezzanine tranche has lower priority than the senior tranche and is promised a higher coupon. The lowest priority tranche that bears the first loss is the equity tranche. The size of the equity and mezzanine tranches provides subordination for the senior tranche. Internal credit enhancement, such as overcollateralization and excess spread, buffers the senior tranches from losses. Likewise, external wraps and insurance also protect the senior bondholders.

LO 28.c

A waterfall structure details the distribution of collateral cash flows to the different classes of bondholders. The equity tranche typically receives the residual cash flows once the senior and mezzanine investor claims are satisfied. If the cash flows to equity holders exceed the overcollateralization trigger, the excess is diverted to a trust account. Fees and defaults will reduce the net cash flows available for distribution.

LO 28.d

Securitization is a complicated process and typically involves an originator, underwriter, credit rating agency, servicer, and manager. The originator creates the initial liability; the underwriter pools and structures the terms of the deal as well as markets the issue; the credit rating agency is an active participant suggesting/requiring sufficient subordination and enhancements to justify the ratings; the servicer collects and distributes the cash flows to investors and manages distress resolution; managers, both static and active, usually bear the first loss to mitigate conflict of interest in asset selection and credit monitoring.

LO 28.e

The three-tiered waterfall will have scheduled payments to senior and mezzanine tranches. The equity tranche receives cash flows only if excess spread > 0 (i.e., interest collected > interest owed to senior + mezzanine). The overcollateralization account increases from recovery of defaulted assets and diversion of spread (usually a maximum is predetermined) and earns the money market rate.

LO 28.f and LO 28.g

If excess spread is negative (i.e., interest collected < interest owed to senior + mezzanine), the OC account will use all of its available funds until depleted. The terminal cash flows are more complicated: redemptions at par + interest from surviving loans + recovery in final period + terminal OC account. No funds are diverted in the final year as it all is aggregated and disbursed. Senior claims are paid first; if senior is paid in full, mezzanine claims are paid; if mezzanine is paid in full, the residual accrues to equity holders.

LO 28.h

Simulation is a useful technique to provide more insight into the performance of the collateral and, hence, cash flows to the tranches. In particular, the default intensity can be time-varying and estimated using a hazard distribution. The correlation between loans is critical to the performance of the pool, so various default probability/correlation pairs are used. Copulas could be used to simulate the timing of the defaults. Finally, simulations allow computation of VaRs for each tranche.

LO 28.i

Increasing default probability will decrease all tranches unconditionally. In contrast, increasing correlation will impact each tranche differently. In general, increasing default correlation increases the likelihood of extreme portfolio behavior (very few or many defaults).

Credit VaR can be used to measure the value of the tranches in the left tail. Increasing the correlation increases the VaR of all tranches. In contrast, increasing the probability of default decreases equity VaR and increases senior VaR.

LO 28.j

Default sensitivities are measured analogously to DV01 and spread '01 by shocking the default probability up and down by 10 basis points. Default sensitivities are always positive and are largest when the resulting loss is close to the attachment point.

LO 28.k

Similar to equity portfolios, systematic risk is present in credit portfolios. Extreme loss events are captured by high default correlations. The thinness of the equity and mezzanine tranches implies that conditional losses are likely to be large. A less granular pool (fewer but larger loans) is more likely to experience a tail event, all else equal.

LO 28.l

Implied default correlations for each tranche can be backed out of the tranche pricing model similar to how the implied volatility is calculated for the Black-Scholes-Merton model.

LO 28.m

Loan originators help create securitizations by selling loans into a trust. They are attracted to secured borrowing via securitization because it provides a lower cost of funding than alternatives such as retaining loans. Investors purchase the bonds and equity in a securitization. They are attracted to securitization because it allows them to invest in diversified loan pools that are typically reserved for banks.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 28.1

1. **B** Senior tranches are perceived to be the safest, so they receive the lowest coupon. The equity tranche receives residual cash flows and no explicit coupon. Although the mezzanine tranche is often thin, the equity tranche is typically the thinnest slice. (LO 28.b)

2. **A** The interest rate on the loans = 4% (market reference rate) + 3% (spread) = 7%. Therefore, the total collateral cash flows in the first period = 100 × $500,000 × 7% × (1 − 0.02) = $3,430,000. The senior tranche receives $50 million × 0.75 × (4% + 2%) = $2,250,000. Similarly, the mezzanine tranche receives $50 million × 0.20 × (4% + 6%) = $1,000,000. Next, the residual cash flows are calculated: $3,430,000 − $2,250,000 − $1,000,000 = $180,000. Since $180,000 < $1,000,000, all cash flows are claimed by the equity investors and there is no diversion to the trust account. (LO 28.c)

Module Quiz 28.2

1. **C** The custodian and trustee play the least important roles in the securitization process. The servicer, originator, underwriter, credit rating agency, and manager all face conflicts of interest to varying degrees. (LO 28.d)

Module Quiz 28.3

1. **A** Statement I is true. Increasing default correlation increases the likelihood of more extreme portfolio returns (very high or very low number of defaults). The increased likelihood of high defaults negatively impacts the senior tranche. On the other hand, the increased likelihood of few defaults benefits the equity tranche as it bears first loss. Statement II is false. At high default rates, increasing the correlation increases the likelihood of more extreme portfolio returns which benefits equity investors and mezzanine investors. (LO 28.i)

2. **C** Starting with observed market prices and a pricing function for the tranches, it is possible to back out the implied correlation to calibrate the model price with the market price. The computation of implied correlation assumes constant pairwise correlation. Both credit default swap and tranche values are observed. Observed tranche values are used in conjunction with risk-neutral default probabilities to compute implied correlation. (LO 28.l)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Hull, Chapter 24.

READING 29

CREDIT RISK

Study Session 5

EXAM FOCUS

This topic is focused on credit risk, which is the risk that the other side of a transaction (in a derivatives contract) or a borrower will default on their obligation. Credit ratings, default probabilities, and recovery rates all play a significant role in determining credit risk. For the exam, be able to calculate default probabilities using credit spreads, and understand default probabilities in both risk-neutral and real-world scenarios. Also, be aware of the credit risk for derivatives and the tools that are used to mitigate this risk. In addition, from the bank's perspective, know the differences between credit and debt (debit) valuation adjustments. Finally, be familiar with the Gaussian copula model, which is used for default probability calculations and estimating credit VaR.

MODULE 29.1: DEFAULT PROBABILITIES

LO 29.c: Calculate the probability of default using credit spreads.

Credit risk is the exposure faced by an individual or entity due to the default potential of both counterparties in derivatives contracts and individuals/entities that borrow money. Three credit ratings agencies that provide corporate bond ratings include Moody's, S&P, and Fitch. The highest rated bonds are considered investment grade, as they pose the lowest risk to bondholders. Credit risk becomes a greater concern with lower rated bonds. The Moody's data in Figure 29.1 reflects average cumulative default rates from 1970 to 2015.

Figure 29.1: Moody's Average Cumulative Default Rates, 1970–2015 (%)

Rating	Term (In Years)								
	1	2	3	4	5	7	10	15	20
Aaa	0.000	0.011	0.011	0.031	0.087	0.198	0.396	0.725	0.849
Aa	0.022	0.061	0.112	0.196	0.305	0.540	0.807	1.394	2.266
A	0.056	0.170	0.357	0.555	0.794	1.345	2.313	4.050	6.087
Baa	0.185	0.480	0.831	1.252	1.668	2.525	4.033	7.273	10.734
Ba	0.959	2.587	4.501	6.538	8.442	11.788	16.455	23.930	30.164
B	3.632	8.529	13.515	17.999	22.071	29.028	36.298	43.368	48.071
Caa-C	10.671	18.857	25.639	31.075	35.638	41.812	47.843	50.601	51.319

As shown by the shaded area in Figure 29.1, bonds rated Baa and above are considered **investment-grade bonds**. The probabilities of default for investment-grade bonds are significantly lower than they are for **non-investment-grade bonds**.

An interesting result from this data is how default probabilities relate over time. The probability that a bond rated Baa will default in Year 3 is 0.831% − 0.480% = 0.351%. In Year 4, it is 1.252% − 0.831% = 0.421% (which is *higher* than in Year 3). For a bond rated B, the probability of a Year 3 default is: 13.515% − 8.529% = 4.986%. For Year 4, it is 17.999% − 13.515% = 4.484% (which is *lower* than in Year 3). The conclusion is that investment-grade bonds may see financial health deteriorate over time, while non-investment-grade bonds may see financial health recover after making it past the critical early years.

The unconditional default probability (i.e., the probability of a default in a given year, as seen today) can be illustrated using data from Figure 29.1. The following is for a B-rated bond:

- Unconditional default probability during Year 4: 17.999% − 13.515% = 4.484%
- Probability of survival through Year 3: 100% − 13.515% = 86.485%
- Probability of a default during Year 4, conditional on no earlier default: 0.04484/0.86485 = 5.185%

The **hazard rate** (i.e., default intensity) is a measure of the probability of default, given a condition of no earlier default. Using the hazard rate, the **probability of default**, *Q(t)*, can be defined as:

$$Q(t) = 1 - e^{-\bar{\lambda}(t) \times t}$$

where:

$\bar{\lambda}(t)$ = average hazard rate between time 0 and time t

A bond's **recovery rate** can be calculated by dividing its market value post-default by its face value. Recovery rates are naturally higher for first and second lien bonds versus those for subordinated bonds. Corporate bond recovery rates reflect a negative dependence on default rates such that strong economic conditions produce lower default numbers and higher recovery rates, whereas weaker economic conditions produce higher default numbers and lower recovery rates.

Default Probabilities Using Credit Spreads

The yield spread of a bond is the difference between the promised yield on the bond and the risk-free rate. Default probabilities can be estimated using bond yield spreads. If *s(T)* is the average loss rate on a bond per year, the average hazard rate can be approximated as:

$$\bar{\lambda}(T) = \frac{s(T)}{1 - RR}$$

For example, a one-year bond yielding 125 basis points above the risk-free rate with a recovery rate of 55% would produce an average hazard rate of: 0.0125/(1 − 0.55) = 0.0278, or 2.78% per year. Greater precision can be found by aligning hazard rates with bond prices such that the hazard rate for the first period is calculated using the shortest maturity bond, and the hazard rate between the first and second period is calculated using the next shortest maturity bond, etc.

The risk-free rate, which is a critical factor in default probability calculations, is typically a Treasury rate. However, there is concern that these rates are too low to truly proxy risk-free rates. A better measure may be credit default swap (CDS) spreads, which do not depend on the risk-free rate. An asset swap spread may also be used, as the present value of the spread is the difference between the price of the risk-free bond and the price of the corporate bond.

Default Probability Estimate Comparisons

Bond yield spreads tend to produce higher estimated default probabilities than those estimated from historical data, with that difference further exacerbated during times of crisis (like the credit crisis of 2007–2009). Figure 29.2, which is derived from Merrill Lynch published data on 7-year bond yields between 1996 and 2007, illustrates the expected excess return on bonds (in basis points) for spreads over Treasuries at various rating categories.

Figure 29.2: Expected Excess Return on Bonds (in bps)

Rating	Bond Yield Spread Over Treasuries	Spread of Risk-Free Rate Over Treasuries	Spread for Historical Defaults	Excess Return
Aaa	78	42	2	34
Aa	86	42	5	39
A	111	42	12	57
Baa	169	42	22	105
Ba	322	42	108	172
B	523	42	294	187
Caa	1146	42	464	640

Evidence has shown that for investment-grade companies, the ratio of the hazard rate derived from bond prices to the hazard rate derived from historical data is very high. However, this ratio subsequently declines as ratings decline such that the spread between the hazard rates increases. Interestingly, a small expected excess return on the

bond comes from larger percentage differences between hazard rates. As credit quality declines, this expected excess return increases.

The hazard rates (default probabilities), which are implied from credit spreads, are considered "risk neutral," which means they can be used to calculate forecasted cash flows when there is credit risk in a risk-neutral world. Expected cash flows are discounted at a risk-free rate. When historical data is used, hazard rates are considered "real-world" (physical) default probabilities. Risk-neutral probabilities tend to be much higher than real-world probabilities, although in theory they would be the same if there were no expected excess returns.

These differences in risk-neutral and real-world probabilities may stem from the relative illiquidity of corporate bonds. Another reason may be higher subjective default probabilities from bond traders. The biggest reason for the difference is that bond defaults are not independent of one another. Some years have low default rates across the board, while others have substantially higher default rates.

Systematic risk, which cannot be mitigated through diversification, stems from the year-to-year variation in default risk. While conditions in the economy can drive systematic risk, credit contagion may also create risk as the default of one company can drive the defaults of others. Nonsystematic risks unique to each bond are also an element to consider, as bond returns have a high skew with limited upside. This makes diversification difficult, thereby driving bond trader returns for bearing both systematic and nonsystematic risks.

In terms of which default probability estimate to use, the guidance is as follows:

- **Risk-neutral default probabilities.** Use these when estimating the impact of default risk on instrument pricing or when valuing credit derivatives.
- **Real-world default probabilities.** Use these when carrying out scenario analyses to calculate potential future losses from defaults.

Equity Prices for Default Probability Estimates

Because credit rating revisions tend to be infrequent, equity prices may be a better source for more up-to-date information on default probabilities. The **Merton model** shows that equity, E_T, is essentially a call option on the value of the company's assets, V_T, with a strike price equivalent to the required debt repayment, D:

$$E_T = \max(V_T - D, 0)$$

Based on the Black-Scholes-Merton formula, the value of equity today is equal to:

$$E_0 = V_0 N(d_1) - D e^{-rT} N(d_2)$$

where:

$$d_1 = \frac{\ln(V_0/D) + (r + \sigma_v^2/2)T}{\sigma_v \sqrt{T}}$$

$$d_2 = d_1 - \sigma_v \sqrt{T}$$

The value of the debt today is then computed as:

$$D_0 = V_0 - E_0$$

Suppose that the market value of the debt (using the equation $V_0 - E_0$) is 8.25, and that the present value of the promised payment on the debt is 8.41. In this case, the expected loss on the debt is approximating (8.41 – 8.25)/8.41 = 1.90% of its no-default value.

Historical data suggests that the Merton model produces solid rankings of default probabilities under both risk-neutral and real-world scenarios.

MODULE QUIZ 29.1

1. If the unconditional default probability of a Ba-rated bond during Year 3 is 1.914% and the probability of survival through Year 2 is 97.413%, the probability of a default during Year 3, conditional on no earlier default, is closest to:
   A. 0.673%.
   B. 1.914%.
   C. 1.965%.
   D. 2.587%.

2. A 2-year corporate bond yields 190 basis points above the risk-free rate. With a recovery rate of 35%, the average hazard rate for Years 1 and 2 is closest to:
   A. 0.67%.
   B. 1.55%.
   C. 2.92%.
   D. 5.43%.

MODULE 29.2: CREDIT RISK IN DERIVATIVES

LO 29.a: Assess the credit risks of derivatives.

An **International Swaps and Derivatives Association (ISDA) Master Agreement** is typically used to govern bilaterally cleared derivatives between two companies. Initial and variation margin requirements must be stated in the agreement for transactions between financial institutions. For variation margin calculations only, transactions are netted.

The agreement also provides the situations where an "event of default" occurs. Two situations exist where the nondefaulting party will likely incur a loss:

1. Total value for the nondefault party is positive and exceeds the default party posted collateral. The nondefault party then assumes the role of an unsecured creditor for an amount equivalent to the value of the transactions less the value of collateral.
2. Total value for the default party is positive and is less than the nondefault party posted collateral. The nondefault party then assumes the role of an unsecured creditor for the return of the excess collateral posted.

CVA and DVA

LO 29.b: Define credit valuation adjustment (CVA) and debt valuation adjustment (DVA).

From the perspective of a bank, the **credit valuation adjustment (CVA)** and **debt (debit) valuation adjustment (DVA)** are defined as follows for a given counterparty:

- CVA is the present value of the expected cost to the bank if the counterparty defaults.
- DVA is the present value of the expected cost to the counterparty if the bank defaults.

For each of its counterparties, the bank will have one CVA and one DVA. These can be considered derivatives, which change in value due to market variables, counterparty credit spreads, and bank credit spreads. Because a bank default implies the bank will not have to make payments on its derivatives position, the DVA (which is of course a cost to the counterparty) is a benefit and an increase to the value of the derivatives portfolio for the bank.

The no-default value to a bank for its outstanding derivatives transactions (f_{nd}) assumes neither side will default. As such, the value of derivatives transactions, accounting for defaults, is reflected as:

$$f_{nd} - \text{CVA} + \text{DVA}$$

The CVA and DVA formulas are expressed as:

$$\text{CVA} = \sum_{i=1}^{N} q_i \times v_i$$

$$\text{DVA} = \sum_{i=1}^{N} q_i^* \times v_i^*$$

where:

q_i = risk-neutral probability of the counterparty defaulting during the ith interval

v_i = present value of the expected loss to the bank if the counterparty defaults at the midpoint of the ith interval

q_i^* = risk-neutral probability (calculated from the bank's credit spreads) of the bank defaulting during the ith interval

v_i^* = present value of the expected loss to the counterparty (gain to the bank) if the bank defaults at the midpoint of the ith interval

Note that the calculation for the q_i term, which represents the probability of the counterparty defaulting during the ith interval, is:

$$q_i = \exp\left(-\frac{s(t_{i-1})t_{i-1}}{1-\text{RR}}\right) - \exp\left(-\frac{s(t_i)t_i}{1-\text{RR}}\right)$$

where:

$s(t_i)$ = counterparty's credit spread

Extensive Monte Carlo simulations are often needed to perform these calculations. Peak exposure at the midpoint of each interval in the event of default is an additional calculation banks perform. The impacts of new transactions on CVA and DVA can be calculated quickly because banks will often store all sampled paths from their

simulations for all market variables. The incremental effects on CVA and DVA from the new transaction are relatively straightforward to discern. A new transaction, which is positively (negatively) correlated to existing transactions, will likely increase (decrease) CVA and DVA.

Two terms related to CVA and DVA calculations are *wrong-way risk* and *right-way risk*. Wrong-way risk occurs when the probability of default is positively correlated with exposure, and right-way risk occurs when the probability of default is negatively correlated with exposure.

Credit Risk Mitigation

LO 29.d: Describe, compare, and contrast various credit risk mitigants and their role in credit analysis.

Banks have several ways in which they can attempt to reduce credit risk in bilaterally cleared transactions. These methods include netting, collateral agreements, and downgrade triggers:

- **Netting.** As an example, four uncollateralized transactions with a counterparty are valued at: +$5 million, −$7 million, +$10 million, and −$2 million. Independently, the bank's exposure is $5 million and $10 million together (or, $15 million). Note that the negative amounts do not represent exposures for the bank. By netting, the total exposure is reduced to $6 million (i.e., 5 − 7 + 10 − 2).
- **Collateral agreements.** Cash or marketable securities are often used as collateral. In the event of a default, the party that did not default can keep the collateral posted by the defaulting party.
- **Downgrade triggers.** These are clauses in Master Agreements between banks and nonfinancial counterparties. The clause states that if the counterparty credit rating falls below a certain level, the bank can choose to close out outstanding transactions at market value or require collateral to be posted. The value of these triggers is reduced if there are big downgrades in counterparty credit ratings or if the counterparty has triggers in place with multiple dealers.

As noted earlier, extensive Monte Carlo simulations are often needed to calculate CVA and DVA. This is actually not necessary in a situation where the transaction portfolio between the bank and counterparty is just a single (uncollateralized) derivative with a payoff to the bank at time *T*. The bank exposure in the future is the no-default derivative value at that time, where the present value is the no-default value today.

If the DVA is zero, the value *f* of the derivative today (accounting for credit risk) is equal to:

$$f = f_{nd} - (1 - RR) f_{nd} \sum_{i=1}^{N} q_i$$

For the value of a *T*-year zero-coupon bond issued by the counterparty with *nd* again representing a no-default situation, the value of the bond is equal to:

$$B = B_{nd} - (1 - RR)B_{nd}\sum_{i=1}^{N} q_i$$

These two equations can be rearranged such that:

$$\frac{f}{f_{nd}} = \frac{B}{B_{nd}}$$

Note that the value of the derivative can be determined by increasing the applied discount rate on the expected payoff (in a risk-neutral environment) by the counterparty's *T*-year credit spread.

MODULE QUIZ 29.2

1. In a bilaterally cleared derivatives transaction between two companies (Company A and Company B), Company B defaults. The value for Company A is a positive $50,000 and the collateral posted by Company B is $30,000. In this situation, Company A is a(n):
   A. secured creditor in the amount of $20,000.
   B. secured creditor in the amount of $80,000.
   C. unsecured creditor in the amount of $20,000.
   D. unsecured creditor in the amount of $80,000.

2. A bank is assessing the impact of a new transaction on CVA and DVA. If the new transaction is negatively correlated to existing transactions, the impact will likely be a(n):
   A. increase to both CVA and DVA.
   B. decrease to both CVA and DVA.
   C. increase to CVA and decrease to DVA.
   D. decrease to CVA and increase to DVA.

3. Bank TGF has three uncollateralized transactions with JL Co. The transactions have values to the bank of: +$12 million, −$4 million, and −$3 million. If the bank mitigates its credit risk through netting, the impact of this technique will result in an exposure reduction of:
   A. $5 million.
   B. $7 million.
   C. $8 million.
   D. $12 million.

MODULE 29.3: DEFAULT CORRELATION AND CREDIT VaR

LO 29.e: Describe the significance of estimating default correlation for credit portfolios and distinguish between reduced form and structural default correlation models.

Default correlation represents the likelihood that two companies will default around the same time. This can happen for a myriad of reasons:

1. External events tend to impact companies in the same geographic region or industry.
2. Overall economic conditions can lead to higher average default rates in some years relative to other years.

3. Contagion where one party defaulting may cause another to default. Because of default correlation, credit risk cannot be fully diversified away.

Two models used to evaluate default correlation include reduced-form models and structural models:

- **Reduced-form models.** These models assume hazard rates are correlated with macroeconomic variables and follow random processes. They are relatively straightforward from a mathematical sense and reflect trends in default correlations due to economic cycles. However, the range of achievable default correlations is low as it is unlikely any two companies will default over the same short period of time.
- **Structural models.** These models are based on models similar to the Merton model (described earlier), and default correlations between companies are introduced by assuming correlated stochastic processes for the assets of both companies. Unlike reduced-form models, the correlation can be set as high as needed. However, the computation time is significant.

Gaussian Copula Model

LO 29.f: Describe the Gaussian copula model for time to default and calculate the probability of default using the one-factor Gaussian copula model.

To determine the time to default, a **Gaussian copula model** may be used. This model is used to quantify the correlation between the probability distributions of times to default for multiple companies, under the assumption that all companies will eventually default. Both real-world and risk-neutral default probabilities may be used:

- *Real-world probabilities.* The left tail is estimated from rating agency data.
- *Risk-neutral probabilities.* The left tail is estimated from bond prices.

Although the probability distributions of company times to default are not "normal," the Gaussian copula model transforms the times to default into normal variables with means of zero and unit standard deviations. The assumption that the joint distribution of the variables is bivariate normal is considered the *Gaussian copula*, which allows the correlation structure of the variables to be estimated independent of their unconditional (marginal) distributions. The default correlation is called the **copula correlation**.

A one-factor model may be used to avoid the need for different correlations between each company pair in the Gaussian copula model. This assumption is given in the following formula:

$$x_i = a_i F + \sqrt{1 - a_i^2}\, Z_i$$

where:

a_i = correlation of company i equity returns with a market index

F = common factor, which impacts defaults for all companies

Z = factor impacting only one company i

Conditioned on the common factor (F), the default probability, Q_i, is equal to:

$$Q_i(T \mid F) = N\left(\frac{N^{-1}[Q_i(T)] - a_i F}{\sqrt{1 - a_i^2}}\right)$$

When the probability distributions of default are the same for all companies, and the correlations are the same for all companies (i.e., common correlation ρ), the default probability equation can be restated as:

$$Q(T \mid F) = N\left(\frac{N^{-1}[Q(T)] - \sqrt{\rho}\,F}{\sqrt{1 - \rho}}\right)$$

Credit VaR

LO 29.g: Describe how to estimate credit VaR using the Gaussian copula and the CreditMetrics approach.

Credit value at risk (VaR) is defined within a specific confidence level as the credit risk loss that will not be exceeded over a given period of time. So, a credit VaR with a one-year time horizon and a 98.5% confidence level is the credit loss we are 98.5% confident will not be exceeded over that one-year period of time. Given *X*% certainty over *T* years, the percentage of losses on a large portfolio will be less than *V(T, X)*, where:

$$V(T, X) = N\left(\frac{N^{-1}[Q(T)] + \sqrt{\rho}\,N^{-1}(X)}{\sqrt{1 - \rho}}\right)$$

This formula uses *Q(T)* as the probability of default by time *T* and the copula correlation as ρ. Credit VaR can then be estimated as: L × (1 − RR) × V(T, X), with the loan portfolio as *L* and the recovery rate as *RR*.

Another approach to estimating credit VaR is with the **CreditMetrics model** (from JPMorgan), where a probability distribution of credit losses is determined by applying a Monte Carlo simulation to the credit rating changes of all counterparties. Although this can be time consuming from a computation standpoint, it does account for both defaults and downgrades. Also, credit mitigation strategies such as the ones described earlier can be incorporated into the model.

For CreditMetrics, a rating transition matrix can be used as a basis for performing Monte Carlo simulation. However, credit rating changes for counterparties are not assumed to be independent when sampling for credit loss estimates. A joint probability distribution for rating changes can be constructed using a Gaussian copula model, with the copula correlation between rating transitions for two companies set equal to their equity return correlations.

MODULE QUIZ 29.3

1. Which of the following statements is most accurate regarding reduced-form versus structural models used to estimate default correlation?
   A. Structural models tend to take a long time to process.
   B. Reduced-form models are more computationally intensive.
   C. Reduced-form models allow for very high default correlations.

D. Economic cycle impacts on default correlation trends are best reflected in structural models.

2. The Gaussian copula model transforms which of the following factors into normal variables?
   A. Recovery rates.
   B. Times to default.
   C. Credit spread risk.
   D. Default probabilities.

3. Assuming a loan portfolio of L, a recovery rate of RR, and the percentage of losses on a portfolio less than $V(T, X)$, which of the following formulas is used to estimate credit VaR?
   A. L × (RR) × V(T, X).
   B. L × (1 − RR) / V(T, X).
   C. V(T, X) / [L × (1 − RR)].
   D. L × (1 − RR) × V(T, X).

KEY CONCEPTS

LO 29.a

An International Swaps and Derivatives Association (ISDA) Master Agreement is typically used to govern bilaterally cleared derivatives between two companies. Initial and variation margin requirements must be stated in the agreement for transactions between financial institutions.

Two situations exist where the nondefault party will likely incur a loss and will become an unsecured creditor: (1) total value for the nondefault party is positive and exceeds default party posted collateral and (2) total value for the default party is positive and less than the nondefault party posted collateral.

LO 29.b

From the perspective of a bank, the credit valuation adjustment (CVA) and debt (debit) valuation adjustment (DVA) are defined as follows for a given counterparty:

- CVA is the present value of the expected cost to the bank if the counterparty defaults.
- DVA is the present value of the expected cost to the counterparty if the bank defaults.

For each of its counterparties, the bank will have one CVA and one DVA.

The no-default value for outstanding derivatives transactions assumes neither side will default. As such, the value of derivatives transactions for the bank, accounting for defaults, is reflected as:

$$f_{nd} - \text{CVA} + \text{DVA}$$

A new transaction, which is positively (negatively) correlated to existing transactions, will likely increase (decrease) CVA and DVA.

Wrong-way risk occurs when the probability of default is positively correlated with exposure, and right-way risk occurs when the probability of default is negatively correlated with exposure.

LO 29.c

The yield spread of a bond is the difference between the promised yield on the bond and the risk-free rate. Default probabilities can be estimated using bond yield spreads.

The risk-free rate, which is a critical factor in default probability calculations, is typically a Treasury rate. Although a better measure to use may be credit default swap (CDS) spreads, which do not depend on the risk-free rate. An asset swap spread may also be used, as the present value of the spread is the difference between the price of the risk-free bond and the price of the corporate bond.

Bond yield spreads tend to produce higher estimated default probabilities than those estimated from historical data. For investment-grade companies, the ratio of the hazard rate derived from bond prices to the hazard rate derived from historical data is very high. However, this ratio subsequently declines as ratings decline such that the spread between the hazard rates increases.

The hazard rates (default probabilities), which are implied from credit spreads, are considered "risk neutral," which means they can be used to calculate forecasted cash flows when there is credit risk in a risk-neutral world. When historical data is used, hazard rates are considered "real-world" (physical) default probabilities. Risk-neutral probabilities tend to be much higher than real-world probabilities. The biggest reason for the difference is that bond defaults are not independent of one another. Some years have low default rates across the board, while others have substantially higher rates.

Systematic risk, which cannot be mitigated through diversification, stems from the year-to-year variation in default risk. Nonsystematic risks unique to each bond are also an element to consider, as bond returns have a high skew with limited upside. This makes diversification difficult, thereby driving bond trader returns for bearing both systematic and nonsystematic risks.

Because credit rating revisions tend to be infrequent, equity prices may be a better source for more up-to-date information on default probabilities. The Merton model shows that equity is essentially a call option on the value of the company's assets with a strike price equivalent to the required debt repayment. Historical data suggests that the Merton model produces solid rankings of default probabilities under both risk-neutral and real-world scenarios.

LO 29.d

Banks have several ways in which they can try to reduce credit risk in bilaterally cleared transactions. These methods include netting, collateral agreements, and downgrade triggers.

Although Monte Carlo simulations are often needed to calculate CVA and DVA, this is not needed when the transaction portfolio between the bank and counterparty is just a single (uncollateralized) derivative with a payoff to the bank at time T. The bank exposure in the future is the no-default derivative value at that time, where the present value is the no-default value today.

LO 29.e

Default correlation represents the likelihood that two companies will default around the same time, which happens due to: (1) external events impacting companies in the same geographic region or industry, (2) overall economic conditions leading to higher average default rates, or (3) contagion where one party defaulting may cause another to default.

Two models used to evaluate default correlation are reduced-form models (easy to calculate, lower default correlations) and structural models (higher correlations, but slower to process).

LO 29.f

To determine the time to default, a Gaussian copula model can be used to quantify the correlation between the probability distributions of times to default for multiple companies. Both real-world and risk-neutral default probabilities may be used.

The Gaussian copula model transforms the times to default into normal variables with means of zero and unit standard deviations. The assumption that the joint distribution of the variables is bivariate normal is considered the Gaussian copula. The default correlation is called the copula correlation. A one-factor model may be used, which assumes that a common factor impacts defaults for all companies.

LO 29.g

Credit risk VaR is defined within a specific confidence level as the credit risk loss that will not be exceeded over a given period of time. So, a credit VaR with a one-year time horizon and a 98.5% confidence level is the credit loss we are 98.5% confident will not be exceeded over that one-year period of time.

One approach to estimating credit VaR is the CreditMetrics model, where a probability distribution of credit losses is determined by applying a Monte Carlo simulation to the credit rating changes of all counterparties. A rating transition matrix can be used as a basis for performing Monte Carlo simulation. A joint probability distribution for rating changes can be constructed using a Gaussian copula model, with the copula correlation between rating transitions for two companies set equal to their equity return correlations.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 29.1

1. **C** The probability of a default during Year 3, conditional on no earlier default, is equal to: 0.01914 / 0.97413 = 1.965%. (LO 29.c)

2. **C** A 2-year bond yielding 190 basis points above the risk-free rate with a recovery rate of 35% would yield an average hazard rate of: 0.0190 / (1 − 0.35) = 0.0292, or 2.92% per year. (LO 29.c)

Module Quiz 29.2

1. **C** The total value for Company A (as the nondefault party) is positive, and at $50,000, it exceeds the $30,000 collateral posted by Company B (as the default party). Company A will be an unsecured creditor for an amount equal to $50,000 − $30,000 = $20,000. (LO 29.a)

2. **B** If a new transaction is negatively correlated to existing transactions for the bank and the counterparty, the new transaction will likely decrease both the CVA and the DVA. (LO 29.b)

3. **B** If the bank treats all three transactions as individual transactions, the exposure is $12 million. If the transactions are netted, the exposure is $5 million. This equates to an exposure reduction of $7 million. (LO 29.d)

Module Quiz 29.3

1. **A** Structural models are computationally intensive (relative to reduced-form models), and, therefore, take a long time to process. However, an advantage to structural models is that they allow for higher default correlations. Economic cycle impacts on default correlation trends are best reflected in reduced-form models. (LO 29.e)

2. **B** The Gaussian copula model transforms the times to default into normal variables with means of zero and unit standard deviations. The other choices are all relevant in the credit risk world, but they are not transformed into normal variables via this model. (LO 29.f)

3. **D** The appropriate formula for estimating credit VaR is: $L \times (1 - RR) \times V(T, X)$. (LO 29.g)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Hull, Chapter 25.

READING 30

CREDIT DERIVATIVES

Study Session 5

EXAM FOCUS

Credit derivatives are financial instruments that are used to hedge credit risk exposures. This topic focuses on the main types and structures of credit derivatives, including credit default swaps (CDSs), total return swaps (TRSs), and collateralized debt obligations (CDOs). For the exam, understand the applications of these credit derivative products, and be able to explain how to value a CDS by computing the CDS spread. Also, be familiar with the process for valuing synthetic CDOs. In addition, understand the role that default correlation plays in CDO valuation.

MODULE 30.1: CREDIT DEFAULT SWAPS

LO 30.a: Describe a credit derivative, credit default swap (CDS), total return swap, and collateralized debt obligation (CDO).

Credit Derivative Products

One critique of traditional credit risk mitigation techniques is that they do not unbundle the credit risk from the underlying asset. Credit derivative products, such as credit default swaps, total return swaps, and collateralized debt obligations are over-the-counter financial contracts that respond directly to this critique. Payoffs for these instruments are contingent on changes in the credit performance or quality of a specific underlying issuer. Therefore, these tools directly enable one party to transfer the credit risk of a reference asset to another party without ever selling the asset itself. In doing so, credit derivative products also aid in price discovery aimed at isolating the economic value of default risk.

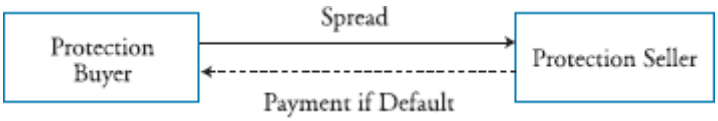
Consider an example of the usefulness of credit derivatives. Bank A specializes in lending to the airline industry, while Bank B specializes in lending to energy firms. When energy prices are high, the energy firms tend to do well, while airlines languish. The reverse is true when energy prices are low. Bank A and Bank B could mitigate their credit risk by either directly selling 50% of their loans to each other, or they could use credit derivatives to more cost effectively meet the same need.

Investors and financial institutions can use credit derivatives to accomplish several goals. Credit derivatives can provide access to specialized risk factors for both risk mitigation and speculation. As mentioned, these credit products also unbundle credit risk from ownership of an underlying asset, effectively creating two unique tradable assets. Credit derivatives also provide yield enhancement and a mechanism to hedge industry-specific and country-specific risks borne by an investor or institution. Hedge funds, and other speculative investors, also use credit derivatives to exploit arbitrage opportunities.

Credit Default Swaps

The most popular form of credit derivative is the **credit default swap (CDS)**. It is a contract that involves a *protection buyer* (insured) paying a periodic CDS spread to a *protection seller* (insurer) for protection against default on a reference obligation. The protection buyer makes these CDS spread premiums until the maturity of the swap or until default, whichever comes first. Unlike regular insurance policies, CDS premiums are paid in arrears (i.e., at the end of the settlement period) as opposed to the start of a settlement period.

Figure 30.1: Credit Default Swap Structure



In case of a default, because the premium is paid in arrears, an accrual payment for the period between the last settlement date and the default date is due from the protection buyer, and the protection seller makes the payment for losses due to default. For example, a 5-year CDS with annual settlement would have the first payment due at the end of the first year. If default occurs three months after the first settlement, the protection buyer owes the pro rata premium for three months as the accrual payment.

The CDS underlying instrument can be a single company or country or a credit index. Many CDS contracts are standardized per ISDA terms and have common maturities of 1, 3, 7, and 10 years with quarterly settlements on March 20, June 20, September 20, and December 20. For example, if a CDS is initiated on April 15 under these terms, the first payment on June 20 will cover the period April 15–June 20.

The *N*-year CDS premium should be approximately equal to the risk premium on a *N*-year risky bond over the benchmark rate (i.e., the market reference rate). Suppose an investor purchases a 7-year corporate bond yielding 7% (3% higher than the benchmark rate). Simultaneously, the investor purchases protection at a cost of 3%. The net return to the investor is 4%, which is the benchmark rate. In the event of default, the investor is made whole by the protection seller (i.e., the bond is exchanged for par value). The **CDS-bond basis** is computed as:

$$\text{CDS-bond basis} = \text{CDS spread} - \text{bond yield spread}$$

The bond yield spread is calculated relative to the market reference rate. To prevent arbitrage, the CDS-bond basis should be close to zero for swaps with the same maturity

as the reference obligation.

The **recovery rate** is the percentage of the par value of a bond that the bond trades at immediately after default. CDS contracts specify any number of bonds with the same seniority issued as the reference obligation (and issued by the same issuer) that can be delivered upon default by the protection buyer to the protection seller for full face value. So, the protection buyer will deliver the **cheapest-to-deliver (CTD) bond**, and the recovery rate is based on the price of the CTD. For example, if the CTD trades at a price of $53 for a $100 par value bond, the recovery rate is 53%.

CDS Valuation

LO 30.b: Explain how to account for credit risk exposure in valuing a CDS.

The **CDS spread** or credit spread on a reference obligation is the compensation for bearing credit risk. The CDS spread (s) is calculated using the following inputs: (1) swap maturity, (2) risk-free rate, (3) hazard rate (i.e., default intensity), and (4) recovery rate.

While the hazard rate, λ, is a constant parameter, the probability of default (PD) at time t declines with the **probability of survival (PS)** over time:

- Probability of survival at time $t = PS_t = e^{-\lambda \times t}$
- Probability of default in year $t = PD_t = (PS_{t-1} - PS_t)$

As an example, suppose that a 3-year CDS has a hazard rate of 3%. The recovery rate is assumed to be 35%, and the continuously compounded risk-free rate is equal to 4%. In this case, we assume annual settlement and that default occurs in the middle of the year.

The probabilities of survival for each year of the swap are computed as follows:

- Year 1: $e^{-1 \times 0.03} = 0.97045$
- Year 2: $e^{-2 \times 0.03} = 0.94176$
- Year 3: $e^{-3 \times 0.03} = 0.91393$

The probability of survival at $t = 0 = 100\%$, or 1. Therefore, the PD in Year 1 = 1 − 0.97045 = 0.0296. Similarly, the PD in Year 2 = 0.97045 − 0.94176 = 0.0287, and the PD in Year 3 = 0.94176 − 0.91393 = 0.0278.

Figure 30.2: Probabilities of Survival and Default, Hazard Rate = 3%

Year	Probability of Survival	Probability of Default
1	0.97045	0.0296
2	0.94176	0.0287
3	0.91393	0.0278

Suppose that the CDS spread = s%. Figure 30.3 shows the expected payment for each of the three years in the swap. Note that the payment is made only if there is no default:

$$\text{expected payment} = \text{probability of survival} \times \text{notional principal} \times s$$

Figure 30.3: Calculation of PV of Expected Payment ($1 Notional)

Year	Probability of Survival	Expected Payment	Discount Factor	PV of Expected Payment
1	0.97045	0.97045*s*	0.9608	0.9324*s*
2	0.94176	0.94176*s*	0.9231	0.8693*s*
3	0.91393	0.91393*s*	0.8869	0.8106*s*
			Total PV	**2.6123*s***

We discount the expected payment at the risk-free rate of 4%. For example, the discount factor at $t = 1$ is: $e^{-0.04\times1} = 0.9608$. The PV of the expected payment is then computed as:

$$\text{PV of expected payment} = \text{discount factor} \times \text{expected payment}$$

Therefore, the total PV of expected payment over the life of the swap = 2.6123*s*.

Because the protection buyer makes the payments in arrears and because the default is assumed to occur in the middle of the year, there is a final payment (i.e., accrual payment) that the protection buyer needs to make in the year of the default (representing the CDS spread for half the year or $s/2$). Figure 30.4 shows the calculation of the PV of the expected value of these accrual payments. Note that the probabilities used now are probabilities of default as the accrual payment is made only upon default.

Figure 30.4: Calculation of PV of Expected Accrual Payment ($1 Notional)

Year	Probability of Default	Expected Accrual Payment	Discount Factor	PV of Expected Accrual
0.5	0.0296	0.0148*s*	0.9802	0.0145*s*
1.5	0.0287	0.0143*s*	0.9418	0.0135*s*
2.5	0.0278	0.0139*s*	0.9048	0.0126*s*
			Total PV	**0.0406*s***

Therefore, over the life of the swap, the total PV of expected payments made by the protection buyer = 2.6123*s* + 0.0406*s* = 2.6529*s*.

Now, we turn our attention to calculating the PV of the expected payoff paid by the protection seller under the assumption of a 35% recovery rate. Recall the assumption that default occurs in the middle of the year and the payoff would occur at that time. Figure 30.5 shows these calculations.

Figure 30.5: Calculation of PV of Expected Payoff ($1 Notional)

Year	Probability of Default	Recovery Rate	Expected Payoff	Discount Factor	PV of Expected Payoff
0.5	0.0296	35%	0.0192	0.9802	0.0188
1.5	0.0287	35%	0.0187	0.9418	0.0176
2.5	0.0278	35%	0.0181	0.9048	0.0164
				Total PV	**0.0528**

The expected payoff for the protection seller is computed as:

$$\text{expected payoff} = (1 - \text{recovery rate}) \times \text{PD} \times \text{notional principal}$$

Assuming default in Year 2 (or Year 1.5, because default is assumed to occur in the middle of the year):

$$\text{expected payoff} = 0.65 \times 0.0287 \times \$1 = 0.0187$$

The PV of the expected payoff is then equal to the expected payoff multiplied by the discount factor.

The CDS spread for this 3-year deal is computed using the following equation and solving for *s*:

$$\text{PV of E(payments)} = \text{PV of E(payoff)}$$

$$2.6529s = 0.0528$$

$$s = 0.0528 / 2.6529 = 0.0199, \text{ or } 1.99\%, \text{ or } 199 \text{ bps}$$

MODULE QUIZ 30.1

1. Modus Corp's 7-year, 5% coupon bond is rated AA. The annual CDS spread on a 7-year bond is 3%. The swap spread is flat at 25 bps, while the swap fixed rate is 3% for 5 years and 4% for 7 years. To prevent arbitrage, Modus Corp's bond should most likely yield:
   A. 7.00%.
   B. 7.25%.
   C. 7.75%.
   D. 8.00%.

2. Xeta Corp's hazard rate is estimated to be 2% over the next five years. The probability of default in Year 2 for Xeta is closest to:
   A. 1.94%.
   B. 1.98%.
   C. 2.00%.
   D. 2.23%.

3. CDS spreads are calculated such that the PV of:
   A. accrual payments is zero.
   B. expected payoff is less than the PV of expected payments during the life of the CDS.
   C. expected payoff is equal to the PV of expected payments during the life of the CDS.

D. expected payoff is greater than the PV of expected payments during the life of the CDS.

MODULE 30.2: CDS EXTENSIONS AND CREDIT INDICES

LO 30.c: Identify the default probabilities used to value a CDS.

The PD used in the previous example is not the true PD. Rather, it is the **risk-neutral (RN) probability of default**. The RN probability of default is the probability implied in the CDS spread quoted in the market. Suppose in the previous example that the actual market CDS spread is 2.75%. In this case, the hazard rate assumption of 3% is too low. By using trial and error (or SOLVER in Excel), the hazard rate should actually be closer to 4.15%.

The other input needed in calculating CDS is the recovery rate (RR). If we calculate the RN probability of default (implied by the market price), then our estimate of the RR does not matter (we still will get to the market spread in our calculations).

The RN probability of default is approximately proportional to 1 / (1 – RR). If we assume a high RR, then the RN probability of default will also be high (keeping the actual market CDS spread quote constant).

Marking a CDS to Market

CDS contracts are *marked to market* (MtM) daily. If the CDS spread narrows (widens), the protection buyer loses (gains) while the protection seller gains (loses) an equal amount. The MtM value of the swap to the protection seller is computed as:

$$\begin{aligned}\text{MtM value to protection seller} = &\ \text{PV of expected payments} \\ &- \text{PV of expected payoff}\end{aligned}$$

EXAMPLE: MARK TO MARKET OF A CDS

Suppose the 3-year swap in the previous example was originally a 3.5-year swap initiated six months ago at a spread of 1.50%. Recall that with three years remaining, the PV of expected payments and the PV of payoff were 2.6529*s* and 0.0528, respectively, and *s* was equal to 1.99%. **Calculate** the mark-to-market value of the swap to the protection seller with a notional principal of $1 million.

Answer:

Using the 1.50% original spread, the PV of expected payments = 2.6529 × 0.015 = 0.0398 per $1 notional. The PV of the expected payoff with three years remaining is unchanged at 0.0528 per $1 notional.

$$\text{Value to protection seller} = \text{PV of expected payments} - \text{PV of expected payoff}$$

$$= 0.0398 - 0.0528 = -0.013 \text{ per \$1 notional principal}$$

$$\text{Swap value to protection seller} = -0.013 \times 1{,}000{,}000 = -\$13{,}000$$

$$\text{Swap value to protection buyer} = +\$13{,}000$$

Because the swap spread has widened from 1.50% to 1.99% in the six months since inception, the protection buyer gains, and the protection seller suffers a loss.

Binary CDS

Binary CDS are like regular CDS, except that the payoff on default is the full notional, regardless of the recovery rate (RR). The CDS calculations only change for Figure 30.5 (because RR is changed to 0%). Figure 30.6 shows the new calculations using the data from the previous example. The sum of the PV of expected payments remains 2.6529*s*.

Figure 30.6: PV of Expected Payoff on Binary CDS ($1 Notional)

Year	Probability of Default	Expected Payoff	Discount Factor	PV of Expected Payoff
0.5	0.0296	0.0296	0.9802	0.0290
1.5	0.0287	0.0287	0.9418	0.0270
2.5	0.0278	0.0278	0.9048	0.0252
			Total PV	**0.0812**

The spread on this binary CDS to computed as:

$$s = 0.0812 \,/\, 2.6529 = 0.0306 = 3.06\%$$

Using the original RR of 35%, the spread on a binary CDS could also be calculated as:

$$\text{binary CDS spread} = \text{vanilla CDS spread} \,/\, (1 - \text{RR})$$

$$= 1.99 \,/\, (1 - 0.35) = 3.06\%$$

As expected, with a 0% recovery assumption, the calculated spread of 3.06% for a binary CDS is higher than the 1.99% spread for a vanilla (or regular) CDS. Therefore, the price to purchase protection in a binary CDS is higher.

Credit Indices

LO 30.d: Evaluate the use of credit indices and fixed coupons in pricing CDS transactions.

CDS indices cover multiple issuers, allowing market participants to take on an exposure to the credit risk of several companies simultaneously in the same way that stock indices allow investors to take on an equity exposure to several companies at once. In this case, the protection for each issuer is equal (i.e., equally weighted), and the total notional principal is the sum of the protection on all issuers.

CDX NA IG (North American issuers) and **iTraxx Europe** (European issuers) each have an equally-weighted exposure to 125 investment-grade companies. Similar indices representing high-yield issuers also exist.

Suppose that the CDX NA IG CDS spread is 50 bps. A trader can obtain $100,000 notional amount protection on each of the 125 companies for the following amount:

$$\text{annual payment} = 125 \times 0.005 \times 100{,}000 = \$62{,}500, \text{ or } \$500 \text{ per company}$$

If one of the companies in the index defaults, the following occurs: the contract continues with 124 remaining companies, a payoff based on (1 – RR) on $100,000 notional is made by the protection seller, and the annual payment is adjusted to 124 × 0.005 × 100,000 = 62,000 (a reduction of $500 going forward accounting for the one default).

The CDS index spread is approximately equal to the average credit spread on the index constituents. The index itself is updated twice a year (applicable only for new contracts signed after the update) whereby the companies whose ratings drop below investment grade are replaced by other investment-grade companies.

Fixed Coupons

Standardization of CDS contracts improves the liquidity of the CDS market. Standardized contracts have a fixed coupon rate payable by the protection buyer instead of the actual CDS spread. The difference between the coupon rate and the spread is settled up front using the following payment:

$$\text{up-front premium \%} = D \times (s - c)$$

where:
D = CDS payment duration (equal to 2.6529 in the previous example)
s = CDS spread
c = coupon rate

The price of the CDS contract computed from the quoted spread is expressed as:

$$\text{price} = 100 - [100 \times D \times (s - c)]$$

> **EXAMPLE: UP-FRONT PAYMENT**
>
> The 5-year CDX NA IG CDS have a fixed coupon rate of 100 bps. If the CDS spread is 65 bps, and the duration of the 5-year CDS is 4.125, **calculate** the up-front premium for a contract with $100,000 notional per company.
>
> **Answer:**
>
> $$\text{Price} = 100 - [100 \times 4.125 \times (0.0065 - 0.01)] = 101.44, \text{ or}$$
> $$\text{up-front premium} = 1.44\%$$
>
> Because the price is > 100, the protection seller pays the protection buyer. This makes sense, given that the protection buyer is committing to paying a higher coupon of 100 bps compared to the justified spread of 65 bps. The amount that the protection seller pays to the buyer is computed as:

up-front payment by seller $= 125 \times 100{,}000 \times 0.0144 = \$180{,}000$

CDS Forwards and Options

LO 30.e: Define CDS forwards and CDS options.

CDS forwards allows a party to enter into a specific CDS as a protection buyer or seller at a fixed CDS spread for a fixed term, but starting at a specified future time period. For example, a party can enter into a forward contract on a 5-year CDS at a spread of 100 bps starting one year from today. The counterparty similarly agrees to be a protection seller in that CDS. If the reference entity defaults, the forward contract ceases to exist.

CDS options allow the holder to enter into a CDS at a strike CDS spread as a protection buyer or seller in exchange for the payment of an option premium. An option to enter into a 2-year CDS as a protection buyer at a strike price of 100 bps would be exercised if the CDS spread is higher than 100 bps. Just like forwards, if the reference entity defaults before the maturity of the option, the option ceases to exist.

MODULE QUIZ 30.2

1. Banko, Inc., entered into a $5 million notional, 5-year CDS as a protection buyer two years ago at a spread of 1.85%. The current 3-year CDS spread for the same reference entity is 2.30% based on the PV of expected payoff of 0.0312 per $1 notional. The value of the CDS to Banko, Inc., is closest to:
   A. −$45,000.
   B. −$30,900.
   C. +$30,500.
   D. +$53,000.

2. If one of the entities in the CDX NA IG index defaults, the CDS index would most likely:
   A. make a payoff and be discontinued.
   B. continue with a replacement entity, with no change to the notional principal.
   C. continue with 99 entities, and the notional principal of each entity would be reduced by 1%.
   D. continue with 124 entities, and the notional principal of each entity would remain the same.

3. Which of the following statements about CDS forwards and CDS options is most accurate?
   A. CDS forwards entered at market rates require a premium payment, while CDS options do not.
   B. CDS options entered at market rates require a premium payment, while CDS forwards do not.
   C. Both CDS forwards entered at market rates as well as CDS options require a premium payment.

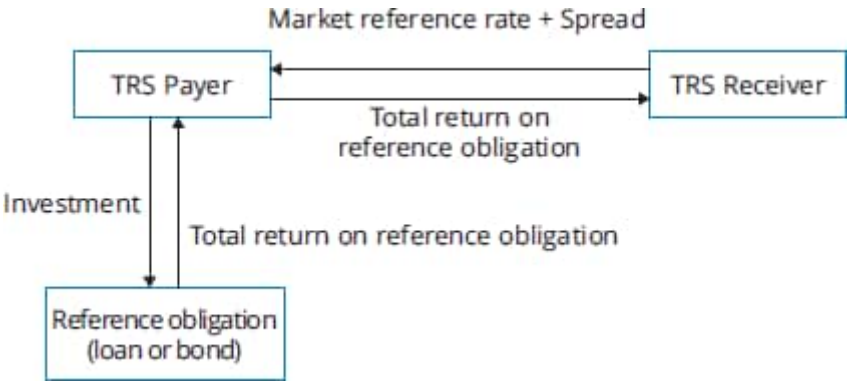
D. Neither CDS forwards entered at market rates nor CDS options require a premium payment.

MODULE 30.3: TOTAL RETURN SWAPS AND COLLATERALIZED DEBT OBLIGATIONS

Total return swaps (TRSs) entail one party paying the total return (i.e., coupon/dividend plus change in price) of an asset in exchange for a fixed or floating rate. For risky bonds, TRSs are not a pure credit derivative as they hedge both credit risk and interest rate risk. As a financing tool, TRSs allow an investor to indirectly fund the purchase of a risky bond.

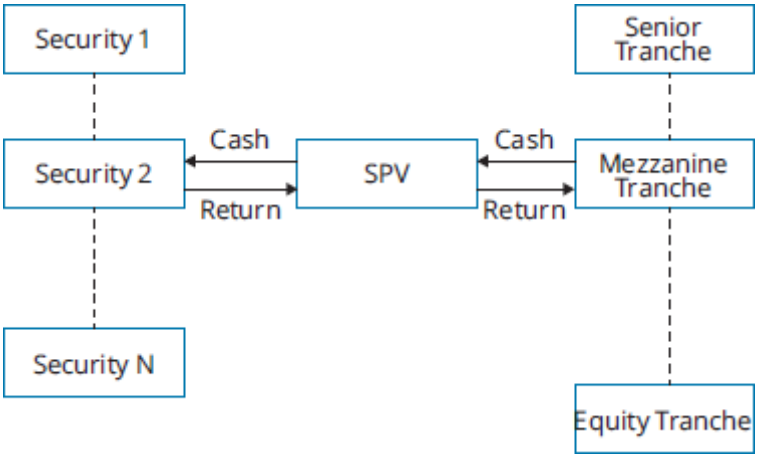
Consider an investor wanting to purchase $20 million worth of a corporate bond. The investor enters into a TRS to receive the total return on that bond with a notional amount of $20 million and pays the market reference rate plus 50 bps. Effectively, the investor has borrowed $20 million at the market reference rate plus a spread of 50 bps to finance the purchase of the corporate bond. The 50 bps spread compensates the TRS payer for the credit risk of the TRS receiver as well as the correlation between the credit risk of the corporate bond and the credit risk of the TRS receiver. At swap maturity, the TRS payer is responsible for paying any bond price *appreciation* to the TRS receiver. In turn, the TRS receiver is responsible for paying any bond price *depreciation* to the TRS payer.

Figure 30.7: Total Return Swap Structure



Collateralized debt obligations (CDOs) are claims against a portfolio of risky debt securities. These claims are divided into tranches, with the senior tranche bearing lower credit risk relative to the junior tranches. A distribution waterfall specifies the distribution of cash flow generated from the portfolio to various tranches of the CDO.

Figure 30.8: A CDO With *N* Underlying Securities



Synthetic CDOs

LO 30.f: Describe the process of valuing a synthetic CDO using the spread payments approach and the Gaussian copula model of time to default approach.

A **synthetic CDO** has similar credit risk exposure to that of a cash CDO, but is instead assembled using CDS rather than actual debt securities. A protection seller effectively gains exposure to credit risk without purchasing the specified bonds. The CDO notional principal is equal to the sum of notional principals of all of the CDS contracts on different bonds for which protection is sold. The originator then receives CDS spreads from the protection buyers and pays out any default losses.

Consider a $100 million notional synthetic CDO representing $4 million each in 25 bonds with an average CDS spread of 2%. Annual spread cash flow equals $2 million. The CDO has three tranches, which are equity, mezzanine, and senior:

1. The *equity tranche* representing 5% of the CDO notional ($5 million) absorbs the highest level of credit risk and is responsible for the first 5% of credit losses due to swap payouts. In return, the equity tranche investors receive 10% per year ($0.5 million). As losses are absorbed, the tranche principal is reduced, and the return is paid on the reduced principal. Once the losses exceed 5%, the equity tranche gets wiped out.
2. The *mezzanine tranche* bears credit losses from 5% to 25% (i.e., 20% of total notional or $20 million) after the equity tranche is exhausted. In return, the mezzanine tranche earns a return of 5.625% ($1.125 million) per year.
3. Finally, the remainder of the credit losses in excess of 25% of the total notional of the CDO is borne by the *senior tranche* representing 75% of the notional ($75 million), and in return, this tranche receives a 0.5% return ($0.375 million) per year.

Note that at inception, the total spread payment equals 2%, or $2 million, which is allocated to the three tranches. The distribution waterfall is set such that the senior tranche obtains a very high credit rating.

Because there is no actual cash outlay to purchase risky debt, synthetic CDOs do not need to be funded. If there are credit losses that need to be paid due to the protection seller position, the appropriate tranche investors would need to make deposits to meet the obligation. Typically, the tranche investors post collateral to ensure compliance.

Individual tranches in a CDO trade separately. Liquid markets exist for standard tranches on synthetic CDOs based on credit indices.

Synthetic CDO Valuation

The two approaches for valuing synthetic CDOs (i.e., calculation of the CDS spread) are (1) based on the PV of expected payments and the PV of expected payoff and (2) the Gaussian copula model.

Spread Payments Approach

According to the previous discussion on the CDS spread computation, we can calculate the spread on a single tranche of a synthetic CDO by setting the PV of expected inflow equal to the PV of expected outflow. For a single tranche, the PV of expected inflow depends on the spread payment—which, in turn, depends on the principal outstanding. For simplicity, we assume that the settlement is annual, but the model can be generalized for other settlement time periods. As losses are experienced by the tranche, its outstanding notional principal declines. As before, we assume that losses occur midway through the settlement period.

The expected loss at time *t* is computed as:

$$EL_t = E(NP_{t-1}) - E(NP_t)$$

The CDO tranche expected payoff is:

$$C = \sum_t EL_t \times DF_{t-0.5}$$

The DF_t = PV of $1 received at time *t*. We subtract 0.5 from *t* to account for losses occurring midway through the time period. For example, if a loss occurs in the second year, we are discounting the loss for 1.5 years.

The total spread payments to be received during the life of the CDO is equal to: A × s, where:

$$A = \sum_t E(NP_t) \times DF_t$$

The final accrual period (because of the assumption of a loss midway through the settlement period) is equal to B × s, where:

$$B = \sum_t EL_t \times DF_{t-0.5}$$

Note that the accrual period payment is only for the loss amount. The remaining notional was already accounted for as part of the calculation for *A*.

The total PV of expected cash inflow to tranche investors = s × (A + B), and the total PV of expected cash outflows on account of credit losses = C

Setting these equations equal results in the *breakeven spread* calculation:

$$s = \frac{C}{A + B}$$

For tranches with a standard coupon (spread) s^*, the up-front premium of NP is:

$$[C - s^* \times (A + B)]$$

Gaussian Copula Approach

Because a CDO collateral pool comprises numerous debt obligations, a multivariate distribution of time to default would be applicable. A copula joins a multivariate distribution to its one-dimensional marginal distribution functions. The one-factor **Gaussian copula model** is a popular methodology for pricing CDS tranches. The Gaussian copula model is homogenous in that it assumes that the time to default probability distribution is same for all reference entities (i.e., probability Q(t) for default at time *t* is the same for all companies in the CDO collateral pool). The correlation between different reference entities is modeled using a Gaussian copula function. The correlation of time to default for any pair of companies in the CDO (i.e., the **copula correlation)** is assumed to be a constant ρ.

The unconditional PD is given by Q(t). In a one-factor Gaussian copula model, the *conditional PD*, Q(t|F), is expressed as:

$$Q(t \mid F) = N\left(\frac{N^{-1}[Q(t)] - \sqrt{\rho}F}{\sqrt{1-\rho}}\right)$$

Using a constant hazard rate, λ, calculated as a risk-neutral probability implied in the market price, the *unconditional PD* is computed as:

$$Q(t) = 1 - e^{-\lambda \times t}$$

In any given period, there are two possible outcomes: default or no default. Using the binomial distribution, the probability of exactly *k* defaults out of *n* companies by time period *t* is given as:

$$P(k,t \mid F) = \frac{n!}{(n-k)!k!} Q(t \mid F)^k [1 - Q(t \mid F)]^{n-k}$$

The expected values of the notional principals (hence, the losses absorbed) in each time period for each of the tranches can then be computed using the PD estimated earlier.

Implied Correlation

LO 30.g: Define the two measures of implied correlation: compound (tranche) correlation and base correlation.

If we use the industry standard recovery rate of 40%, the only missing input in estimating the tranche spread is the copula correlation. Similar to calculating implied volatility in option pricing using the Black-Scholes-Merton option pricing model, we can calculate the **implied correlation** priced by the market.

There are two alternative measures of implied correlation. The first is **compound (or tranche) correlation**. For tranche q, this is the value of the correlation that leads to the tranche spread calculated from the model being the same as the spread quoted in the market. It is found using an iterative search. The second is **base correlation**. Starting with the compound correlation for each tranche, an iterative process is used to determine the PV of expected loss for each tranche of the CDO that is consistent with its current market price.

The compound implied correlations exhibit a "correlation smile" pattern whereby the correlation starts out high for junior tranches and declines initially before rising again. Implied base correlations exhibit a "correlation skew" where the correlations rise with tranche seniority. If the market prices were consistent with the one-factor Gaussian copula model, the implied correlations should be the same for all tranches. A pronounced smile or skew pattern is, therefore, inconsistent with market pricing, and is a limitation of the one-factor model.

Gaussian Copula Model Alternatives

LO 30.h: Discuss alternative approaches used to estimate default correlation.

The one-factor Gaussian copula model has some limitations. Namely, it does not account for fat tails in real-world probability distributions for time to default and the evidenced correlation smile/skew.

Alternative models include the following:

1. *Heterogenous models*. These allow for specification of different distributions for time to default for different reference entities included in the collateral pool. However, this model gets significantly more complicated, and we cannot use a binomial model for determining the probability of k defaults at time t.
2. *Other copulas*. These include the Student's t copula, Archimedean copula, the Clayton copula, and Marshall-Olkin copula.
3. *Random recovery rates and factor loadings*. These are based on the negative relationship between default rates and recovery rates.
4. *Implied copula model*. This is simply derived from market prices.
5. *Dynamic models*. These include structural and reduced-form models, which measure the evolution of loss on a collateral pool over time.

MODULE QUIZ 30.3

1. At inception, the tranches in a synthetic CDO are priced to earn a spread that is:
   A. equal for each tranche.
   B. consistent with their seniority.
   C. aggregate in amount to the premium paid to binary CDSs.
   D. higher for senior tranches, as they represent a larger notional principal.

2. Base correlation and compound correlation are both:
   A. tranche correlations.
   B. implied correlations.

C. not relevant for synthetic CDOs.
D. exhibiting a skew with correlations rising with tranche seniority.

3. The structural model of credit risk is most likely a(n):
A. dynamic model.
B. heterogenous model.
C. implied copula model.
D. random recovery rate model.

KEY CONCEPTS

LO 30.a

Credit derivative products, such as credit default swaps (CDSs), are innovations that separate default risk from the underlying security. They offer the ability to insure and transfer specific risks to both investors and insurance sellers.

A CDS is a contract whereby a protection buyer (insured) pays a periodic CDS spread (insurance premium) to the protection seller (insurer) for protection against default on a reference obligation. CDS premiums are paid in arrears until the maturity of the swap or until default, whichever comes first. CDS premiums are set equal to the credit spread on the underlying to prevent arbitrage.

Total return swaps (TRSs) entail one party paying the total return on a bond and receiving a fixed or floating rate in return. TRSs hedge both credit risk and interest rate risk of the bond.

Collateralized debt obligations (CDOs) are claims on a collateral pool comprising risky debt securities. CDO tranches have a defined distribution waterfall whereby the cash flow/losses from the CDO are allocated among different tranches.

LO 30.b

Two factors influence the credit spread: (1) the probability of default (PD) and (2) the recovery rate (RR). The higher (lower) the PD (RR), the higher the credit spread. The credit spread on a CDS is set at the inception of the contract such that the PV of spread payments = PV of payoff (or expected losses).

LO 30.c

CDS pricing models use the risk-neutral (RN) probability of default, which is the PD implied in the CDS spread quoted in the market assuming a certain RR. The RR assumption is not critical as the RN probability will adjust consistent with the market price (if we assume a high RR, the implied PD would also be high, keeping the market price constant).

LO 30.d

CDSs on credit indices allow purchasing (or selling) protection on an equally-weighted portfolio of credit risky bonds. The CDS index spread is approximately equal to the average credit spread on the index constituents.

Standardized CDS contracts have a fixed coupon rather than a market spread payable by the protection buyer. The difference between the coupon rate and the spread is settled up front using the following payment:

$$\text{up-front premium \%} = \text{duration} \times (\text{spread} - \text{coupon})$$

LO 30.e

Forward contracts on a CDS allow parties to lock in a fixed spread for a CDS to commence in the future. For CDS options, the option holder has a right, but not the obligation, to enter into a CDS contract at a fixed price at maturity of the option. The option holder pays an option premium to the option writer to acquire this right.

LO 30.f

A CDO is a debt instrument backed by a collateral pool such that the cash flows from the pool are distributed to various tranches of the CDO based on a prespecified distribution waterfall. A synthetic CDO mimics the cash flows of a regular CDO by selling CDS protection on a collateral pool. The premium income from the CDS serves as the credit spread earned on the pool, while CDS loss payoffs mimic the losses suffered by the collateral pool upon default.

There are two approaches to determining the CDS spread in a CDO:

1. One approach is setting the PV of expected spread payments equal to the PV of expected payoffs.
2. The other approach is the one-factor Gaussian copula model, which models the time to default of each of the securities in the collateral pool using a homogenous distribution. A key factor is the correlation between time to default of the individual bonds in the collateral pool.

LO 30.g

The correlation between the time to default of collateral pool constituents can be estimated as follows:

- There is implied correlation in the current market price of the CDS tranche.
- The implied correlation can be a compound correlation that uses an iterative approach to estimating correlation consistent with the market price of each of the CDO tranches. Alternatively, implied correlation can be a base correlation that starts with the compound correlation and then re-estimates it by setting the PV of expected spread payments equal to the PV of expected losses.

Compound correlations in practice exhibit a “correlation smile” pattern whereby the implied correlations start out high for junior tranches, fall, and then rise again as they move toward more senior tranches. Implied base correlations, on the other hand, exhibit a “correlation skew” rising with tranche seniority. If estimated correctly, correlations should be the same regardless of tranche. This smile/skew pattern is a limitation of the one-factor Gaussian model.

LO 30.h

Alternatives to the one-factor Gaussian copula model include the following:

1. *Heterogenous models*. These allow for specification of different distributions for time to default for different reference entities included in the collateral pool.
2. *Other copulas*. These include the Student's *t* copula, Archimedean copula, the Clayton copula, and Marshall-Olkin copula.
3. *Random recovery rates and factor loadings*. These are based on the negative relationship between default rates and recovery rates.
4. *Implied copula model*. This is derived from market prices.
5. *Dynamic models*. These include structural and reduced-form models, which measure the evolution of loss on a collateral pool over time.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 30.1

1. **A** Arbitrage-free conditions indicate that:

   CDS-bond basis = CDS spread – bond yield spread = 0

   Thus, CDS spread = bond yield spread = 3% (given).

   Bond yield spread = bond yield – swap fixed rate

   3% = bond yield – 4% (make sure to use the 7-year swap fixed rate)

   Therefore, the bond yield = 7%.

   (LO 30.a)

2. **A** The probability of survival in Years 1 and 2 = $e^{-0.02 \times 1}$ = 0.9802 and $e^{-0.02 \times 2}$ = 0.9608.

   The probability of default in Year 2 = 0.9802 – 0.9608 = 0.0194, or 1.94%.

   (LO 30.b)

3. **C** The CDS spread is set such that the PV of expected payoff is equal to the PV of expected payments during the life of the swap. The PV of expected payments includes the PV of expected periodic swap spread payments plus the PV of expected accrual payments. (LO 30.b)

Module Quiz 30.2

1. **C** Recognize that the value of the CDS is calculated such that:

   $$\text{current PV of expected payments} = \text{current PV of expected payoff} = 0.0312$$

   Using the current spread of 2.30%, the current PV of expected payments = 0.023 × s.

   $$s = 0.0312 / 0.023 = 1.3565$$

Applying this value to the initial CDS spread of 1.85% yields:

$$\text{PV of expected payments (based on 1.85\%)} = 0.0185 \times 1.3565 = 0.0251$$

Value to the protection buyer = PV of expected payoff - PV of expected payments

$$= 0.0312 - 0.0251 = 0.0061 \text{ per \$1 notional}$$

The swap value for the $5 million notional = 0.0061 × 5,000,000 = $30,500.

Because the spread has widened, the protection buyer gains. (LO 30.c)

2. **D** The CDX NA IG index has 125 equally-weighted entities. When one of these entities defaults, the existing CDS would continue with 124 entities with the same notional per entity. (LO 30.d)

3. **B** CDS forwards entered at market rates do not require a premium payment. However, CDS options do require a premium payment to the option writer who is willing to take the risk of option exercise. (LO 30.e)

Module Quiz 30.3

1. **B** At inception, the tranches in a synthetic CDO are priced to earn a spread that is consistent with their risk level (i.e., seniority in the distribution waterfall). The aggregate spread amount is set equal to the premium received as a protection seller in a vanilla CDS. While senior tranches normally have a higher notional principal, the spread (as a rate) is lower due to the lower credit risk of the senior tranches. (LO 30.f)

2. **B** Compound (or tranche) correlation and base correlation are implied correlations that are calculated differently. While compound correlations exhibit a smile pattern, base correlations show a skew pattern. (LO 30.g)

3. **A** Dynamic models, including structural and reduced-form models, capture the evolution of loss on a collateral pool over time. Heterogenous models allow for specification of different distributions for time to default for different reference entities included in the collateral pool. Random recovery rates and factor loadings are based on the negative relationship between default rates and recovery rates. The implied copula model is derived from market prices. (LO 30.h)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Gregory, Chapter 2.

READING 31

DERIVATIVES

Study Session 6

EXAM FOCUS

Traditional, noncleared markets rely on bilateral trades that leave both counterparties open to credit (mainly default) risk. By contrast, centrally cleared derivatives use collateralization and margining to reduce counterparty risk. This topic focuses on the differences between exchange-traded and over-the-counter (OTC) derivatives as well as the differences between cleared and noncleared transactions. For the exam, understand the structure of derivatives markets and the different market players, and the role of the central counterparty (CCP) and central clearing in reducing systemic risk. Also, be prepared to explain how entities use different mechanisms to reduce counterparty risk, and be able to identify both their strengths and shortfalls. Finally, be able to discuss the different approaches used for modeling derivatives risk.

MODULE 31.1: TYPES OF DERIVATIVES AND DERIVATIVES MARKETS

LO 31.a: Define derivatives and explain how derivative transactions create counterparty credit risk.

A **derivative** represents a contractual agreement between two parties to buy or sell an underlying security, or to make a payment in the future. Derivatives like many futures contracts may expire in the short term (few weeks), while others, such as long-dated swaps, may expire in several years. The value for derivatives changes over the life of the contract, but many are valued to have zero value at inception for both parties.

Derivatives have existed for a long time, with some of the earliest types dating back centuries. They offer an important tool for entities to hedge their various risk exposures, including interest rate risk (via an interest rate forward or swap), foreign exchange risk (via FX forwards), or commodity price risk (via commodity futures or swaps). They also offer entities a way to gain or reduce their exposure to an underlying security. Consider a farmer who is worried that the price of wheat could decline over the next six months when the crop is harvested. In this case, price risk could be hedged

by taking the short side in (selling) wheat futures that expire in six months, which locks in a known future price for the farmer.

Derivatives are used by a wide range of entities, including corporations, wealth managers, banks, insurance companies, and various forms of governments as well as central banks. Some derivatives (like futures) are standardized, while others (like forwards and swaps) are custom instruments that can be tailored to the specific needs of the parties. Some markets are dominated by large and important derivatives dealers, often large systemically important banks.

Although a key use of derivatives is to hedge risk, they create their own risk: **counterparty credit risk** (a combination of market and credit risk). This is the risk that as the value of the contract changes over time given changing security prices and market conditions, the other party to the transaction will not meet its contractual obligations and will not deliver the security or make a payment. Counterparty risk can be managed bilaterally where each party manages its own risk, or centrally via a central counterparty (CCP).

Derivatives Markets

LO 31.b: Compare and contrast exchange-traded derivatives and over-the-counter (OTC) derivatives, and discuss the features of their markets.

Derivative contracts may be *exchange traded*, which are standardized and created and traded on an exchange, or *over-the-counter (OTC)*, which are customized.

Exchange-traded derivatives, like futures and many options, include terms and conditions that are specified by the exchange, and include specific prices, expiry dates, and notional value of the underlying securities they represent. Standardized contracts facilitate clearing and settlement and promote transparency and accessibility, but their terms generally cannot be altered. Most derivatives exchanges are very liquid.

By contrast, **OTC derivatives** trade on informal global networks often through dealers, and the contracts are private and customized between two counterparties. As a result, these contracts facilitate transferring risks in very precise ways and improve flexibility. Consider a computer manufacturer that needs to buy 1,241 ounces of copper for circuit boards in 133 days. A custom contract can be created in the OTC market as long as the manufacturer can find a counterparty, or a dealer is willing to take the sell side of the transaction.

The main disadvantage is that unwinding a custom, private contract can be very difficult, or could only be done at unfavorable terms. If the counterparty is the dealer, the dealer cannot buy (sell) the derivative at one price and simultaneously sell to (buy from) another party at a better price. Some contracts may be *novated* (assigned to another party), but typically, this can only be done with the permission of the original counterparty. While many OTC derivatives markets are illiquid, some markets (including FX) can be very liquid.

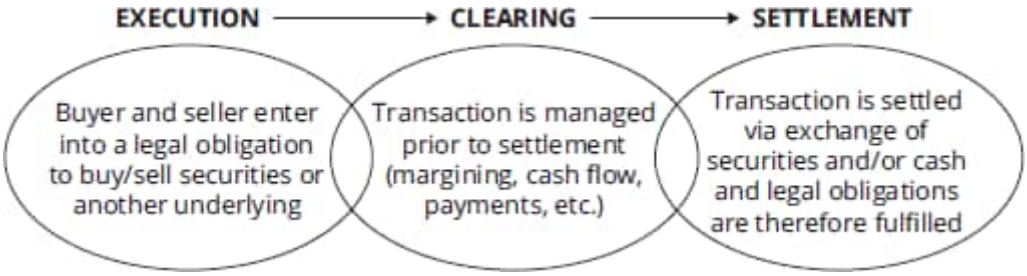
Clearing Derivative Transactions

LO 31.c: Describe the process of clearing a derivative transaction.

Both clearing and settlement are critical functions in derivatives markets. **Clearing** is the process before the settlement of recording the counterparties' identities and computing and facilitating margin and payment obligations. **Settlement** is the related process of facilitating payment and transferring money from one counterparty to the other when the contract is closed out to satisfy their legal obligations. Clearing can be viewed as the period between executing and settling a transaction. Both clearing and settlement are important for managing counterparty credit risk—the risk of a failure in contractual obligations (nonpayment, or nondelivery of an asset). Because derivatives may have very long time horizons, OTC clearing is of growing importance.

In a **bilateral market**, the original counterparty remains unchanged as long as the contract remains in effect, and risk management is done by each counterparty. In a **centrally cleared market**, the original counterparty is replaced by the CCP, which steps into the middle of the transaction and becomes the new counterparty to each side, as well as performs the risk management functions. Figure 31.1 illustrates the relationship between execution, clearing, and settlement.

Figure 31.1: Clearing Financial Transactions


EXECUTION
CLEARING
SETTLEMENT
Buyer and seller enter into a legal obligation to buy/sell securities or another underlying
Transaction is managed prior to settlement (margining, cash flow, payments, etc.)
Transaction is settled via exchange of securities and/or cash and legal obligations are therefore fulfilled

Source: Jon Gregory, *The xVA Challenge: Counterparty Credit Risk*, Funding, Collateral, and Capital (West Sussex, UK: John Wiley & Sons, 2020). Chapter 2.

While OTC markets have historically been primarily bilaterally cleared, central OTC clearing has been gaining prominence. However, because central clearing needs some level of standardization, it is not feasible for all OTC derivatives.

Market Participants and Collateralization in Derivatives Markets

LO 31.d: Identify the participants and describe the use of collateralization in the derivatives market.

Market participants for derivative trades fall into three broad groups, where the groups are segmented based on the size of the derivatives portfolio (but not necessarily the size of the participants).

These three groups are (1) large player, (2) medium-sized player, and (3) end user:

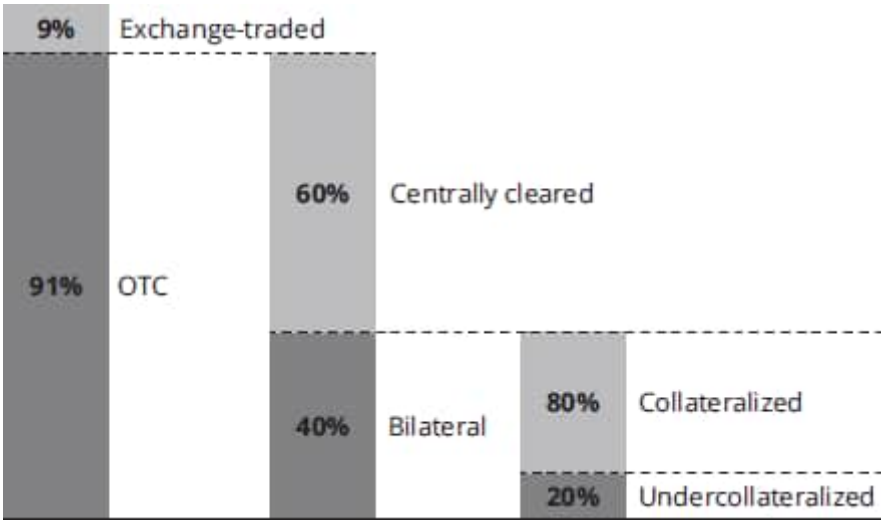
- *Large player*. These are typically large global banks that have a significant derivatives portfolio with a large volume of trades. They trade most types of derivatives, including FX, interest rate, equities, commodities, and credit derivatives, and they provide significant liquidity to the derivatives markets. Large players are members of most exchanges and CCPs and participate as dealers in the OTC markets, controlling around 80% of the notional value of OTC trades.
- *Medium-sized player*. These are usually small banks and financial institutions that have a fair amount of OTC trades across a range of derivative types and are often members of exchanges and CCPs. A typical player is a local or regional bank that needs to hedge its interest rate or various FX exposures. However, they do not trade the whole spectrum of derivatives; for example, they typically do not participate in credit derivatives or commodity or exotic derivatives markets.
- *End user*. End users can be small financial institutions, large corporations, and even sovereign governments that have relatively small or specific derivatives needs, often to hedge a single type of exposure. For example, a pension fund may only need interest rates swaps to hedge its floating rate exposure, while a mining company may only need commodity forwards to hedge its price exposure. End users typically only transact with a small number of counterparties and tend to avoid posting collateral frequently or only post illiquid collateral. Counterparty credit risk is a significant risk in these markets. Nevertheless, some large regional and sovereign governments or supranational entities (which have very high credit quality) can dictate better terms when trading with counterparties (usually banks), including requiring the counterparty to post collateral but not posting collateral themselves, or having favorable rating triggers or other contract terms.

Derivatives can also be classified based on the way they are transacted and collateralized, and fall into four groups: (1) exchange traded, (2) OTC centrally cleared, (3) OTC collateralized, and (4) OTC uncollateralized. Exchange-traded derivatives represent less than 10% of the market and are settled daily with margin. OTC derivatives represent the bulk of the market and are usually not settled daily, but they may be centrally cleared and collateralized. Posting collateral reduces counterparty risk, but it introduces legal and operational risk and funding costs:

- *Exchange traded.* These encompass simple, short-dated, and highly liquid derivatives. All exchange-traded markets are centrally cleared and collateralized, greatly minimizing counterparty credit risk. Counterparties post margin and trades are marked-to-market.
- *OTC centrally cleared*. These include more complex and less liquid OTC derivatives trades that are not well suited for trading on exchanges. However, they are centrally cleared and collateralized with daily variation margin.
- *OTC collateralized*. These are bilateral OTC trades where each counterparty posts cash or security collateral to reduce counterparty credit risk.
- *OTC uncollateralized*. These are bilateral OTC trades that are not collateralized by the counterparties, usually because they do not have or cannot lock up cash or securities. As a result, these are the riskiest derivatives markets.

Figure 31.2 provides a visual representation of the size of these markets.

Figure 31.2: Types of Derivatives by Market Size



Source: Jon Gregory, *The xVA Challenge: Counterparty Credit Risk*, Funding, Collateral, and Capital (West Sussex, UK: John Wiley & Sons, 2020). Chapter 2.

MODULE QUIZ 31.1

1. The process under which margin transactions are facilitated and computed is best referred to as:
   A. clearing.
   B. settlement.
   C. execution.
   D. collateralization.

MODULE 31.2: CENTRAL CLEARING OF DERIVATIVES AND MODELING DERIVATIVES RISKS

ISDA Master Agreement

LO 31.e: Define the International Swaps and Derivatives Association (ISDA) Master Agreement, the risk-mitigating features it provides, and the default events it covers.

Because OTC derivatives trades are privately negotiated between two parties, it was necessary to develop legal documentation that governs the general terms of these contracts. The industry standard is the **ISDA Master Agreement**, introduced in 1985 and widely used since 1992, which was developed by the International Swaps and Derivatives Association (ISDA). Negotiating ISDA Master Agreements can be a time-consuming process, but it is intended to help standardize terms and reduce overall risk to counterparties through the following: (1) contractual terms for posting collateral, (2) events of default and termination, (3) netting of obligations, and (4) defining the closeout process. The main agreement is standard, but it has a schedule that contains

adjustable terms. The law governing these agreements is usually English or New York law.

From the perspective of counterparty credit risk, events of default are critical because a default causes the termination of the agreement and initiates the closeout process. **Events of default** include the following forms, with failure to pay and bankruptcy being the most common:

- Failure to pay or deliver
- Breach of agreement
- Credit support default
- Misrepresentation
- Default under a specified transaction
- Cross-default (i.e., a default on another obligation of the same counterparty)
- Bankruptcy
- Merger without assumption

PROFESSOR'S NOTE
ISDA Master Agreements contain four main parts: a master agreement, a schedule, credit support, and confirmation. Credit support defines the terms of collateral and is typically included under a credit support annex, commonly referred to as the *ISDA CSA* (or just *CSA*).

Credit Derivatives

LO 31.f: Describe the features and use of credit derivatives and discuss potential risks they may create.

Credit derivatives are derivatives that hedge the exposure to credit risk. The most common credit derivative is the credit default swap (CDS), with other common types including total return swaps and credit spread options. Credit derivatives can be an efficient way to transfer credit risk, although speculation in the credit derivatives market (e.g., leading up to the global financial crisis [GFC]) has introduced significant risk—and as a result, growth has slowed in recent years.

A CDS involves one side as the credit protection buyer (seeking protection against the default of a third party) and the other side as the credit protection seller. However, while the CDS is intended to protect against the credit risk of a third party, it introduces credit risk between the two counterparties to the CDS. This credit risk is one of the key reasons for the push toward central clearing of OTC derivatives.

Central Counterparties

LO 31.g: Describe central clearing of OTC derivatives and discuss the roles, mandate, advantages, and disadvantages of the central counterparty (CCP).

Central Clearing and the Role of CCPs

In the wake of the 2007–2009 financial crisis, central clearing of derivatives trades and the role of the **central counterparty (CCP)** became significantly more important to ensure systemic risk mitigation. CCPs provide clearing services for many different types of financial transactions between member firms, and they stand between counterparties as the buyer for every seller and the seller for every buyer.

CCPs perform several critical roles, including:

- setting standards and rules for clearing members;
- closing out the positions of defaulting clearing members;
- requiring initial margin, variation margin, and contributions to a default fund to mutualize losses; and
- establishing a plan for extreme events (e.g., requiring top-ups to the default fund, or haircutting variation margins).

Benefits of CCPs

The CCP structure provides significant credit benefits because it changes the traditional risk landscape, with the CCP being in the middle of all trades. In a traditional bilateral counterparty structure, default risk is directly borne by the individual counterparties. With central clearing, trades are netted and the original counterparties no longer represent credit risk, as the CCP becomes the new counterparty.

CCPs remain market neutral by netting all buy-side transactions with offsetting sell-side transactions. This multilateral netting process requires counterparties to post collateral through a margin account. The end result is less theoretical risk in the system due to mark-to-market collateralization.

In the event of a default of one of the clearing members, the CCP must replace nonperforming transactions not by closing out transactions, but by substituting the defaulted member with another clearing member. Within the CCP structure, counterparty losses are mutualized among all member firms by spreading losses across clearing members. CCPs also facilitate the closeout process by auctioning the defaulting member's obligations with netting—and, therefore, reducing the overall position value and minimizing volatility.

Shortfalls of CCPs

For central clearing to be effective, CCPs must be of extremely strong credit quality. The failure of a CCP could result in a systemic shock. Furthermore, while CCPs help reduce credit risk (and thus, prioritize derivatives counterparties), this could be done at the expense of other market participants like bondholders. Finally, because CCPs

often have cross-border activities, they need to deal with conflicting legal frameworks and regulations.

Margin Requirements for Derivatives

LO 31.h: Explain the margin requirements for both centrally-cleared and non-centrally-cleared derivatives.

As mentioned, clearing members using centrally cleared derivatives must post *initial margin* and *variation margin* and contribute to a default fund to cover the losses of a defaulting clearing member. Initial margin is required on all trades, and variation margin is needed to cover market value changes in the derivatives.

By contrast, noncentrally cleared, bilateral trades historically had no or only limited margin requirements—but in recent years, to mitigate systemic risk, regulators globally have been moving to introduce similar margin requirements for bilateral derivatives trades as those under central clearing.

Counterparty Risk Intermediaries

LO 31.i: Define special purpose vehicles (SPVs), derivatives product companies (DPCs), monolines, and credit derivatives product companies (CDPCs) and describe the limitations of using them as risk mitigating methods.

A **special purpose vehicle (SPV)**, also called a special purpose entity (SPE), is an off-balance sheet, bankruptcy-remote entity that is separate from its sponsor. SPVs are created to reduce counterparty risk, with SPV investors having priority as creditors (known as a *flip provision*). Because of their bankruptcy remoteness and often low leverage, SPVs received high credit ratings from rating agencies. An SPV, in essence, transforms counterparty risk into a type of legal risk.

The legal risk is that a bankruptcy court might consolidate the assets of an SPV with their sponsor in the event of default, which would treat the SPV assets as if they had never been physically transferred off the sponsor's books. This treatment will depend on the jurisdiction, but United States courts have a history of consolidation rulings. Under this scenario, the goal of isolating the originator from counterparty risk with the SPV is often not realized. Other courts, including in the United Kingdom, tend to avoid consolidation rulings unless it involves fraud. In the case of the Lehman Brothers bankruptcy, the U.S. courts ruled that the flip provision was unenforceable. This contradicted the U.K. courts, which ruled that they were.

A **derivatives product company (DPC)** is another entity that evolved out of a need for OTC derivatives markets to manage counterparty risk. A DPC is set up by a financial institution to obtain a very high (typically AAA) credit rating with separate capitalization from the parent. This puts further distance between a DPC and its parent. In this way, if the DPC parent were to fail, the DPC would not suffer losses, which provides a measure of enhanced protection for DPC counterparties.

The credit rating of a DPC depends on the following three factors:

1. *Minimizing market risk*. A DPC will often remain market neutral by trading offsetting contracts. Ideally, these mirrored trades will occur on both sides of every trade so that the counterparty risk is negligible.
2. *Support from the parent*. Similar to an SPV, a DPC is established to be bankruptcy remote from the parent. However, in the event of the parent's failure, a DPC is pre-arranged to either pass to another institution with strong capital, or to gradually unwind all mirrored transactions in an orderly fashion.
3. *Internal credit risk management and operational guidelines*. These guidelines provide another layer of risk mitigation in a DPC, and they generally involve daily marking to market and collateral posting to limit risk exposures.

The concept of an orderly unwinding of a DPC's book does not always hold true in real-world application. When both Lehman Brothers and Bear Stearns failed during the global financial crisis, DPCs from these institutions did not experience orderly unwindings. Two Lehman Brothers DPCs filed for Chapter 11 bankruptcy, while the Bear Stearns DPCs were wound down by JPMorgan. As a result, it is clear that DPCs have significant risks, including legal risk (similar to SPVs) as well as market and operational risk.

Monoline insurance companies (monolines) are highly leveraged insurance companies with a single business line to insure bond repayments, typically under guarantees provided to bond issuers (known as *credit wraps*) to enhance bond ratings. They offer credit enhancements, often in the form of CDSs, for various structured credit products. Unlike DPCs, monolines do not post collateral against their transactions when business conditions are normal, and they retain their very high (usually AAA) credit ratings. However, as insurance valuation losses mounted during the global financial crisis, monolines lost their high credit ratings and were forced to post collateral just at the time that their insured losses increased. This led to the failure of several monolines during 2007–2009.

Credit derivative product companies (CDPCs) are similar to DPCs, but they have business models similar to monolines to provide credit derivative protection, and to profit from offering such protection. As with monolines, CDPCs do not post collateral against their transactions when business conditions are normal, and they retain their AAA credit ratings. CDPCs are usually highly leveraged and carry a great deal of market risk because they do not use offsetting risk positions. Similar to monolines, many CDPCs failed during or shortly after the global financial crisis.

Modeling Derivatives Risk

LO 31.j: Describe the approaches used and the challenges faced in modeling derivatives risk.

The need for a more quantitative assessment of derivatives has led to the introduction of derivatives models like value at risk, potential future exposure, and expected

shortfall, as well as correlations and dependency calculations.

Value at risk (VaR) measures the worst loss over a specified period (typically short term) using a given confidence level (conversely, the minimum loss using a given significance level). For example, a one-month VaR of $100,000 at a 99% confidence level means that there is a 99% probability that the maximum loss in a month is $100,000 (or, there is a 1% probability that the minimum loss will be $100,000). **Potential future exposure (PFE)** is the credit risk equivalent of VaR and has a long time horizon, often measured in years. Because PFE measures counterparty credit risk, it measures credit exposure due to a gain.

VaR has the advantage of summarizing risk in a single number, and it does not depend on the shape of the loss distribution. However, it does not reveal anything about the possible loss beyond the confidence level (i.e., is it $100,001 or $5,000,000?). Furthermore, VaR may not be subadditive. Subadditivity would imply that the risk of two portfolios is the sum of their individual risks.

Expected shortfall (ES) is a modification of VaR that measures the average loss beyond VaR, meaning the average loss knowing that the loss is at least equal to VaR. Both VaR and ES are typically implemented using historical simulation using real, historical data, where the data is then recalculated under different scenarios. The outcomes are then backtested *ex post* to check the models' predictive power.

Most financial institutions combine VaR and ES calculations with other complex quantitative models—using correlation, volatility, and dependence factors—to assess risk in making investment decisions. Modeling of risks has also been increasingly required by regulators. However, many models tend to be viewed on a binary basis (either as good or bad), whereas in reality, their effectiveness or success depends not on the model itself, but on how institutions use them.

Incorporating correlations and dependence into modeling further reveals the shortfalls of models like VaR. Using historical correlations is often a poor predictor of future outcomes. In addition, correlations often change significantly, especially during periods of greater volatility and stress. Dependence between financial variables can also change, where assessing the codependence of various risk factors (credit risk, market risk, collateral) becomes critical.

MODULE QUIZ 31.2

1. Which of the following statements is not an improvement that centrally cleared markets offer relative to bilateral markets? Centrally cleared markets:
   A. remain market neutral by netting trades.
   B. offer more flexibility in contract selection.
   C. formalize the default closeout process by mutualizing losses.
   D. improve counterparty risk by replacing the original counterparty with a series of new counterparties.

2. Which of the following actions is not an advantage of the central counterparty (CCP) in the centralized clearing process?
   A. Loss mutualization.
   B. Eliminate counterparty risk.

C. Improve operational efficiency.
D. Risk reduction through multilateral netting.

3. Which of the following statements is an enhancement offered by the central counterparty (CCP) structure relative to the special purpose vehicle (SPV), the derivative product company (DPC), and the monoline insurance models? The CCP structure:
   A. enables financial institutions to remove assets from their balance sheets.
   B. enables counterparty risk to be outsourced, but in a nondiversified format.
   C. spreads losses over a group of counterparties to minimize potential systemic risk.
   D. enables a counterparty transaction originator to fail and not affect the other member firms.

4. A risk manager at MAB Funds estimates that the fund's one-week value at risk (VaR) is $1 million using a 95% probability. The fund can, therefore, be expected to lose:
   A. an average of $1 million in a week 5% of the time.
   B. an average of $1 million in a week 95% of the time.
   C. no more than $1 million in a week 5% of the time.
   D. no more than $1 million in a week 95% of the time.

KEY CONCEPTS

LO 31.a

A derivative is a contractual agreement between two parties to buy or sell an underlying security, or to make a payment in the future. Derivatives are exposed to counterparty risk, which is a combination of market and credit risk, reflecting market value changes and the risk that the other side will not meet its contractual obligations. Counterparty risk can be managed bilaterally or centrally involving a central counterparty (CCP).

LO 31.b

Exchange-traded derivatives include futures and many options. The exchange specifies the terms and conditions, prices, expiry dates, and notional value, and transactions are centrally cleared and settled.

OTC derivatives include forwards and swaps, and they trade on informal global (dealer) networks. Contracts can be customized (which improves flexibility), unwinding a custom contract can be very difficult or costly, and each side is subject to credit risk.

LO 31.c

Clearing is the process of recording counterparties' identities and calculating margin and payment obligations. Settlement is the process of facilitating payment and transferring money when the contract is closed out. Clearing is the period between execution and settlement of a transaction.

In a bilateral market, each counterparty remains unchanged, and risk management is done by each counterparty. In a centrally cleared market, the CCP becomes the new counterparty to each side of the transaction, and it performs the risk management functions.

LO 31.d

Market participants for derivatives can be segmented into the following groups:

1. *Large players* (global banks) have significant derivatives portfolios and large volumes of trades across a broad spectrum of derivatives.
2. *Medium-sized players* (smaller financial institutions or regional banks) have a fair amount of OTC derivatives trades across a slightly more limited range of derivatives types.
3. *End users* (small financial institutions, large corporations, and sovereign or other governments) have relatively small or specific derivatives needs (e.g., to hedge a single type of exposure). End users generally do not post collateral, and they face significant counterparty risk.

Derivatives can be exchange traded (centrally cleared and collateralized with margin requirements), OTC centrally cleared, OTC collateralized, or OTC uncollateralized.

LO 31.e

OTC derivatives are typically governed under a standardized ISDA Master Agreement, which includes (1) contractual terms for posting collateral, (2) events of default and termination, (3) netting of obligations, and (4) defining the closeout process.

Default causes the termination of the agreement leading to the closeout process. The most common events of default are failure to pay or deliver, and bankruptcy.

LO 31.f

Credit derivatives hedge the exposure to credit risk and include credit default swaps (CDSs), total return swaps, and credit spread options. The two parties to a CDS are the credit protection buyer and the credit protection seller, where both counterparties are exposed to credit risk.

LO 31.g

Central clearing is the process by which the CCP performs trade verifications and netting and margining functions. Overall, the role of the CCP includes the following:

- Setting standards and rules for clearing members
- Closing out the positions of defaulting clearing members
- Requiring initial and variation margin, and default fund contributions
- Planning for extreme events

Benefits of CCPs include the following:

- With the CCP as the counterparty to each trade, default risk is minimized
- CCPs perform multilateral netting and posting collateral, which reduces credit risk
- CCP help mutualize counterparty losses across clearing members
- CCPs facilitate the closeout process

Shortfalls of CCPs include the following:

- The potential failure of a CCP could result in a systemic shock
- CCPs prioritize derivatives counterparties at the expense of other market participants
- CCPs are often exposed to conflicting legal frameworks and regulations in different jurisdictions

LO 31.h

Central clearing requires members to post initial margin and variation margin as well as contribute to a default fund. Noncentrally cleared, bilateral trading historically had no or limited margin requirements, although there is a move toward central clearing of these trades.

LO 31.i

Special purpose vehicles (SPVs) are bankruptcy-remote entities separate from the sponsor. SPVs reduce counterparty risk for investors, and investors have priority as creditors. SPVs transform counterparty risk into legal risk. The legal risk is that a bankruptcy court might consolidate the assets of an SPV with their sponsor in the event of default.

Derivatives product companies (DPCs) are set up by their parent institutions to obtain very high credit ratings and are separately capitalized by the parent so that if the DPC parent were to fail, the DPC would not suffer losses. The credit rating of a DPC depends on the (1) minimizing market risk, (2) support from the parent, and (3) internal credit risk management and operational guidelines.

Monoline insurance companies (monolines) are highly leveraged insurance companies with a single business line to insure bond repayments. They offer credit enhancements for various structured credit products. Monolines do not post collateral against their transactions.

Credit derivative product companies (CDPCs) are similar to both DPCs and monolines. They provide credit derivative protection while also profiting from offering such protection. CDPCs do not post collateral, are highly leveraged, and carry a great deal of market risk.

LO 31.j

Financial institutions use many models to assess risk. Value at risk (VaR) measures the worst loss over a specified short period using a given confidence level. VaR is simple and intuitive and does not depend on the shape of the loss distribution, but it does not reveal anything about the possible loss beyond the confidence level. Potential future exposure (PFE) is the credit risk equivalent of VaR relating to gains using a long time horizon. Expected shortfall (ES) measures the average loss knowing that the loss is at least equal to VaR.

Financial institutions often combine these model types with other complex quantitative models using correlations, volatility, and dependence factors. However,

historical correlations are often poor predictors of future outcomes, and they can change significantly during periods of stress.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 31.1

1. **A** *Clearing* is the process of recording counterparties' identities and calculating margin and payment obligations. *Settlement* is the process of facilitating payment and transferring money when the contract is closed out. *Execution* is the initial step of entering into a derivatives contract. *Collateralization* is the process of posting assets as security to minimize credit risk. (LO 31.c)

Module Quiz 31.2

1. **B** Bilateral markets permit any type of customized financial contract and customized collateral that is freely negotiated between the two bilateral parties. In a centrally cleared market, flexibility is reduced because contracts must be standardized, and collateral rules are fixed and nonnegotiable. (LO 31.g)

2. **B** The centralized clearing process used by a CCP does not fully eliminate counterparty risk, but it significantly reduces or minimizes this risk relative to bilateral transactions. (LO 31.g)

3. **C** Through the collateralization and loss mutualization processes, a CCP spreads losses over a group of counterparties—and, in the process, reduces potential systemic risk. SPVs and DPCs are entities that remove assets from a financial institution's balance sheet. Monolines enable counterparty risk outsourcing in a nondiversified format. In the event that a member fails in the CCP structure, all other member firms are impacted through loss mutualization. It is the DPC that protects itself from the failure of the transaction originator. (LO 31.i)

4. **D** VaR measures the worst loss over a specified short period using a given confidence level. As a result, the risk manager expects that the fund will lose no more than $1 million in a week 95% of the time (or, it will lose at least $1 million 5% of the time). (LO 31.j)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Gregory, Chapter 3.

READING 32

COUNTERPARTY RISK AND BEYOND

Study Session 6

EXAM FOCUS

This reading examines the concept of counterparty credit risk and introduces techniques for mitigating and managing counterparty risk. For the exam, know the basic terminology related to counterparty risk and the definitions and differences among the various credit exposure metrics that are discussed. Also, be familiar with the types of institutions that take on counterparty risk through trading, and have an understanding of how institutions can mitigate and manage this risk.

MODULE 32.1: COUNTERPARTY RISK

Counterparty Risk and Lending Risk

LO 32.a: Describe counterparty risk and differentiate it from lending risk.

Counterparty risk is the risk that a counterparty is unable or unwilling to live up to its contractual obligations (i.e., counterparty defaults). Within the context of derivatives contracts, default occurs at some point after inception but prior to the end of the contract term (i.e., presettlement). If default occurs, current and future payments required by the contract will not be made.

Lending risk has two notable characteristics: (1) the principal amount at risk is usually known with reasonable certainty (e.g., mortgage at a fixed rate) and (2) only one party (unilateral) takes on risk.

Counterparty risk goes further than lending risk because it takes into account that the value of the underlying instrument is uncertain in terms of absolute amount and in terms of which party will have a subsequent gain or loss. In addition, counterparty risk is bilateral in that each party takes on the risk that the counterparty will default; the party that is "winning" takes on the risk that the party that is "losing" will default.

PROFESSOR'S NOTE

Counterparty risk is typically used to refer to risk that occurs prior to settlement (i.e., presettlement risk). However, the term may occasionally be used with regard to settlement risk, which is the risk stemming from the fact that there may be a difference in timing between when each counterparty performs its contractual obligations at settlement. During this period, default can occur, resulting in a large loss for one party as credit exposure is at its highest level during the settlement process. If not specifically defined, assume counterparty risk refers exclusively to presettlement risk.

Transactions With Counterparty Risk

LO 32.b: Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction.

Exchange-traded derivatives do not carry counterparty risk because the exchange is usually the counterparty. Therefore, the focus of this reading will be on securities financing transactions and over-the-counter (OTC) derivatives.

Securities financing transactions include repos and reverse repos, and securities borrowing and lending.

Repos are short-term lending agreements (as short as one day) secured by collateral. The agreement involves a party (the seller or borrower) selling securities to another party (the buyer or lender) for cash, with the seller/borrower buying back the securities at a later date. The lender receives the repo rate, calculated as a risk-free interest charge, plus a counterparty risk charge. Collateral is usually in the form of liquid securities. A haircut is applied to mitigate against the counterparty risk that the borrower will not repay the cash and to mitigate against a decline in the value of the collateral. To illustrate the use of a haircut, assume a 2% haircut on a $100 million loan amount. This means that approximately $102.04 million of securities is required as collateral on a $100 million loan [$100 million / (1 − 0.02) = $102.04 million].

Although reduced by collateral on the loan, counterparty risk still exists in both a repo transaction and a reverse repo transaction (which is a repo, from the perspective of the other party) due to the fact that the seller may fail to repurchase the security at the maturity date (forcing the buyer to liquidate the collateral to recover the cash that was loaned). If securities are used as collateral, risk exists that the market value of the securities will have declined prior to maturity.

Securities borrowing and lending are repos, just with securities involved rather than cash. The associated counterparty risk is similar to that of repos.

OTC derivatives include interest rate swaps (the bulk of the transactions), foreign exchange transactions, and credit default swaps (CDSs).

When comparing an interest rate swap to a regular loan, counterparty risk is reduced for the interest rate swap because there is no exchange of principal. The risk lies in the exchange of floating cash payments versus fixed cash payments. The notion of "netting"

further reduces counterparty risk because only the difference between the two payments (the net amount) is exchanged periodically. As soon as the counterparty defaults on payments, there is no need for the other party to continue making payments.

Foreign exchange forwards carry large counterparty risk due to the need to exchange notional amounts and due to long maturities (thereby increasing the probability that a default will occur at least once).

Credit default swaps carry large counterparty risks due to wrong-way risk and significant volatility (thereby increasing the probability that there will be a "losing" party that will default). Wrong-way risk refers to an increase in exposure when counterparty credit quality worsens. It can be illustrated in a very simplified example whereby a firm invested in Greek sovereign debt wishes to protect its position by purchasing a CDS on Greek sovereign debt from a Greek bank. Assuming a reduction in the rating of Greek sovereign debt, the buyer of the CDS is "winning." However, the ability of the "losing" counterparty (the Greek bank) to meet its obligations will further be impaired as a result of the credit rating decrease.

Institutions That Take on Counterparty Risk

LO 32.c: Identify and describe institutions that take on significant counterparty risk.

The institutions that take on counterparty risk through trading activities vary in size, volume, coverage of asset classes, and their willingness (and ability) to post collateral against their positions. At a high level, these institutions (called "derivatives players" in this context) fall into three categories: large, medium, and small.

Large derivatives players are large banks (dealers) that trade with each other and with a large number of clients. They tend to have high numbers of OTC derivatives on their books and cover a very wide range of assets, including commodities, equity, foreign exchange, interest rate, and credit derivatives. In addition, they will post collateral against their positions.

Medium derivatives players are often smaller banks or financial institutions that also have a large number of clients and conduct a high volume of OTC derivatives trades. While they also cover a wide range of assets, they are not as active in all of them as large players. In addition, it is likely (but not definite) that they will post collateral against positions.

Small derivatives players are sovereign entities, large corporations, or smaller financial institutions with specific derivatives requirements that determine the trades they undertake. Trades are done with only a small number of counterparties, and, as expected, they have few OTC derivatives trades on their books. Unlike large and medium players, small players are likely to specialize in just one asset class. They will also differ from larger players in terms of collateral—which, if posted, will often be illiquid.

While the entities described here take on counterparty risk through trading activity, third parties exist that offer products and services used by market participants to reduce counterparty risks and improve efficiency. These products and services include clearing services, software, trade compression, and collateral management.

Counterparty Risk Terminology

LO 32.d: Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default, and the recovery rate.

Credit exposure (or simply *exposure*) is the loss that is "conditional" on the counterparty defaulting. It can be illustrated with a financial instrument contract between two parties. After inception, assume Counterparty A has a positive value (it is the creditor and is owed money), and Counterparty B has a negative value (it is the debtor and owes money). If Counterparty B defaults, Counterparty A will suffer a loss on the amount owed.

In quantifying exposure, it is not always the case that the full principal amount is at risk. Therefore, a more relevant calculation is replacement cost, together with an assumption of a zero recovery value. Furthermore, calculations must consider current exposure (current claims and commitments), future exposure (potential future claims), and contingent liabilities.

Regarding **credit migration**, the counterparty may default or its credit rating may deteriorate over the term of the contract, especially for long-time horizons. Alternatively, there may be an improvement in credit rating over time. To assess credit migration, we must consider the term structure of **default probability**:

- Future default probability will likely decrease over time, especially for periods far into the future. This is due to the higher likelihood that the default will have already occurred at some earlier point.
- An expected deterioration in credit quality suggests an increasing probability of default over time.
- An expected improvement in credit quality suggests a decreasing probability of default over time.

Empirically, there is mean reversion in credit quality, so the implication is that counterparties with strong credit ratings tend to deteriorate (increasing default probability over time), and those with weak credit ratings tend to improve (more likely to default earlier and less likely later). Default probability of a counterparty can be computed in two ways: a real (historical) measure (identifying the actual default probability) and a risk-neutral measure (computing the theoretical market-implied probability).

Recovery is measured by the recovery rate, which is the portion of the outstanding claim actually recovered after default. For example, a recovery rate of 70% suggests a 30% loss. As discussed earlier in the definition of exposure, recovery is not usually

considered when pricing credit risk. Related to the concept of recovery is **loss given default (LGD)**, which is calculated as 1 – recovery rate.

Mark to market (MtM) is an accrual accounting measure that is equal to the sum of the MtM values of all contracts with a given counterparty. Although in theory it represents the current potential loss, it fails to consider other factors such as netting, collateral, or hedging. MtM is equal to the present value of all expected inflows less the present value of expected payments (positive if in favor of the party and negative if not). MtM is a measure of replacement cost. However, although generally close, current **replacement cost** is not theoretically the same as the MtM value due to factors such as transaction costs and bid-ask spreads.

MODULE QUIZ 32.1

1. When considering counterparty credit risk, which of the following financial products has the largest outstanding notional amount in the marketplace?
   A. Credit default swaps.
   B. Foreign exchange forwards.
   C. Interest rate swaps.
   D. Repos and reverse repos.

2. Liz Parker is a junior quantitative analyst who is preparing a report dealing with credit migration. An excerpt of her report contains the following statements:
   I. Future default probability will likely increase over time, especially for periods far into the future.
   II. When computing the default probability of a counterparty under a risk-neutral measure, we need to first determine the actual default probability.

   Which of Parker's statements is (are) correct?
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. Which of the following statements regarding counterparty credit risk is most accurate?
   A. Counterparty risk is unilateral.
   B. Over-the-counter (OTC) derivatives contain less counterparty risk than exchange-traded derivatives because the counterparty is known.
   C. The precise future value of the contract is uncertain, but the counterparties are aware of whether the future value will be positive or negative.
   D. Counterparty risk is typically associated with counterparty default prior to the settlement rather than default during the settlement process.

MODULE 32.2: MANAGING, MITIGATING, AND QUANTIFYING COUNTERPARTY RISK

LO 32.e: Describe credit value adjustment (CVA) and compare the use of CVA and credit limits in evaluating and mitigating counterparty risk.

LO 32.f: Identify and describe the different ways institutions can quantify,

Managing Counterparty Risk

Methods to manage counterparty risk include the following: trading only with high-quality counterparties, cross-product netting, close-out, collateralization, walkaway features, diversifying counterparty risk, and exchanges and centralized clearinghouses.

Trading only with **high-quality counterparties** is a simple and straightforward method for managing counterparty risk. All of these counterparties would have AAA credit ratings and may not be required to provide collateral.

Cross-product netting works with derivative transactions that can have both a positive and a negative value. In the case of a default by either counterparty, a netting agreement will allow transactions to be aggregated and reduce the risk for both parties. The legal and operational risks that accompany netting must be considered. For example, legal risk materializes if a netting agreement is found to be legally unenforceable. An example of cross-product netting is as follows (from Counterparty A's perspective):

	Counterparty A	Counterparty B
Trades with positive MtM	+$20 million	–$20 million
Trades with negative MtM	–$17 million	+$17 million
Exposure with no netting	+$20 million	+$17 million
Exposure with netting	+$3 million	$0

Close-out is the immediate closing of all contracts with the defaulted counterparty. When combined with netting of MtM values, an institution may offset what it owes to the counterparty (a negative amount) against what it is owed by the counterparty (a positive amount). If the net amount is negative, the institution will make a payment, but if the net amount is positive, it will make a claim. This results in an immediate realization of net gains or losses for the institution.

Collateralization (i.e., margining) occurs in the form of a collateral agreement between two counterparties that reduces exposure by requiring sufficient collateral to be posted by either counterparty to support the net exposure between them. Sufficient collateral does theoretically reduce the net exposure to zero. Posting collateral is done on a periodic basis to minimize transaction costs. However, collateralization does come with market, operational, and legal risks as well as significant work requirements to ensure the process is done properly.

A **walkaway feature** allows a party to cancel the transaction if the counterparty defaults. It is advantageous if a party has a negative MtM and the counterparty defaults.

Diversification of counterparty risk limits credit exposure to any given counterparty consistent with the default probability of the counterparty. When an institution trades with more counterparties, there is much less exposure to the failure of any given counterparty.

As described previously, exchanges and centralized clearinghouses take on the role of the counterparty and guarantee all trades by removing all counterparty risk from trades. However, this may simply redistribute counterparty risk as opposed to completely eliminating the risk.

Mitigating Counterparty Risk

As mentioned, **netting** is commonly used to mitigate counterparty risk. Each party's required payment is computed and then offset so that only the party that "owes" a net amount is required to make that payment to the counterparty. The success of netting depends on the nature of the payments involved and whether they are easy to offset.

A second way to mitigate counterparty risk is the use of **collateralization**. Taking collateral equal to or greater than the notional amount of principal should theoretically eliminate all counterparty risk. However, by taking collateral, there are some administrative costs involved in addition to taking on liquidity risk (i.e., collateral may have to be sold at a significant discount in the short term) and legal risk (i.e., attempting to take title on the collateral may be a long and drawn out legal process).

A third way to mitigate counterparty risk is through **hedging**. Using credit derivatives allows an organization to reduce counterparty exposure to its own clients in exchange for increasing counterparty exposure to clients of a competitor. Therefore, hedging generates market risk.

Central counterparties (e.g., exchanges and clearinghouses) frequently take on the role of the counterparty, which offers another way to mitigate counterparty risk. They are a convenient way to centralize counterparty risks, settle transactions, and reduce the bilateral risks inherent in many derivatives contracts. However, the use of central counterparties does reduce the incentive of parties to carefully assess and monitor counterparty risks. Therefore, using central counterparties generates operational, liquidity, and systemic risks.

Quantifying Counterparty Risk

In general, counterparty risk for a given transaction is quantified on the following levels:

- *Trade level*: considers the nature of the trade and related risk factors.
- *Counterparty level*: takes into account risk mitigating factors such as netting and collateral for each individual counterparty.
- *Portfolio level*: considers overall counterparty risk in that only a small percentage will likely default in a given time period.

Within the context of derivatives pricing, there is a portion that assumes no counterparty risk and a portion that accounts for counterparty risk. The portion that accounts for counterparty risk is known as the **credit value adjustment (CVA)**. A trader's objective is to earn a return greater than the CVA.

The CVA examines counterparty risk at both the trade and counterparty levels. Credit limits, on the other hand, limit exposures at the portfolio level. Thus, the CVA and credit

limits complement each other and are often both used to quantify and manage counterparty risk. The CVA aims to minimize the number of counterparties in an effort to maximize netting benefits, while credit limits aim to maximize the number of counterparties in an effort to achieve greater diversification benefits.

PROFESSOR'S NOTE
The credit value adjustment calculation will be examined in Reading 37.

OTC Derivatives Costs

LO 32.g: Identify and explain the costs of an OTC derivative.

Assessing the lifetime economic costs of OTC derivatives involves identifying whether the transaction has positive or negative MtM. Positive MtM results when a transaction is in the money. In this case, counterparty risk and funding costs arise from any uncollateralized component. For the MtM that is collateralized, the counterparty chooses the type of collateral to post. Negative MtM results when a transaction is out of the money. In this case, counterparty risk arises from the party's own potential for default. A funding benefit will also arise for any collateral that is not posted. For MtM that is collateralized, the party itself chooses the type of collateral to post. In either a positive or negative MtM scenario, there will be funding costs associated with the capital needed for the transaction and the initial margin.

X-Value Adjustment (xVA) Terms

LO 32.h: Explain the components of the X-Value Adjustment (xVA) term.

The impact of counterparty risk, collateral, funding, and capital can be captured with a variety of xVA terms. In general, these components represent a cost, but some components may provide a benefit. One component of xVA is the credit value adjustment (CVA). A related component to CVA is known as the **debt value adjustment (DVA)**. The DVA defines counterparty risk from the party's point of view. Additional xVA components include the following:

- **Funding value adjustment (FVA).** This is the cost and benefit resulting from funding a transaction.
- **Collateral value adjustment (ColVA).** This is the cost and benefit resulting from embedded options in collateral agreements as well as any additional collateral terms.
- **Capital value adjustment (KVA).** This is the cost of holding capital over the duration of a transaction.
- **Margin value adjustment (MVA).** This is the cost of posting margin over the duration of a transaction.

MODULE QUIZ 32.2

1. Ondine Financial, Inc., (Ondine) uses a variety of techniques to manage counterparty risk. It has entered into an interest rate swap with Scarbo, Inc. (Scarbo). Currently, Ondine's position in the swap has a –$1 million mark-to-

market value. Based on the information provided, which of the following credit risk mitigation techniques would be most advantageous to Ondine if Scarbo defaults?

A. Close-out.
B. Collateralization.
C. Netting.
D. Walkaway.

2. Which of the following methods of mitigating counterparty risk is most likely to generate systemic risk?

A. Netting.
B. Collateral.
C. Hedging.
D. Central counterparties.

KEY CONCEPTS

LO 32.a

Counterparty risk is the risk that a counterparty is unable or unwilling to live up to its contractual obligations. Counterparty risk is different than lending risk because the future value of the contract is highly uncertain; for lending risk, the value is quite certain. In addition, counterparty risk is bilateral, whereas lending risk is unilateral.

LO 32.b

Securities financing transactions, such as securities borrowing and lending and repos and reverse repos, carry counterparty risk. Over-the-counter (OTC) derivatives such as interest rate swaps, foreign exchange forwards, and credit default swaps also carry counterparty risk.

LO 32.c

Institutions that take on counterparty risk through trading activities fall into three size categories: large, medium, and small. They vary based on the volume of trades, coverage of asset classes, and their willingness and ability to post collateral.

LO 32.d

Important terminology relating to counterparty risk includes the following: credit exposure, credit migration, recovery, mark-to-market (MtM), replacement cost, default probability, recovery rate, and loss given default.

LO 32.e

Counterparty risk is quantified at the trade, counterparty, and portfolio levels. Within the context of pricing a derivative, there is a portion that assumes no counterparty risk and a portion that accounts for counterparty risk. The latter portion is the credit value adjustment (CVA). The CVA acts at both the trade and counterparty levels, while credit limits act at the portfolio level. Thus, the CVA and credit limits are complementary.

LO 32.f

Methods to manage counterparty risk include the following: trading only with high-quality counterparties, cross-product netting, close-out, collateralization, walkaway

features, diversifying counterparty risk, and exchanges and centralized clearing houses.

Netting, collateralization, hedging, and central counterparties are some common ways to mitigate counterparty risk.

LO 32.g

The lifetime economic costs of OTC derivatives examine if the transaction has positive or negative MtM. Positive MtM results when a transaction is in the money, and negative MtM results when a transaction is out of the money.

LO 32.h

The economic impact of counterparty risk, collateral, funding, and capital can be captured with a variety of xVA terms. These terms include the credit value adjustment (CVA), debt value adjustment (DVA), funding value adjustment (FVA), collateral value adjustment (ColVA), capital value adjustment (KVA), and margin value adjustment (MVA).

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 32.1

1. **C** There are two classes of financial products where counterparty risk exists: over-the-counter (OTC) derivatives and securities financing transactions such as repos and reverse repos. OTC derivatives are significantly larger with interest rate swaps comprising the bulk of the market. (LO 32.b)

2. **D** Future default probability will likely decrease over time, especially for periods far into the future. This is because of the higher likelihood that the default will have already occurred at some earlier point. In computing the default probability of a counterparty under a risk-neutral measure, one needs to compute the theoretical market-implied probability; the actual default probability applies under a real (historical) measure. (LO 32.d)

3. **D** Counterparty risk is a bilateral risk in that both parties are unaware of the eventual value of the contract and they do not know whether they will earn a profit or loss. For exchange-traded derivatives, the counterparty is the exchange, which effectively mitigates counterparty risk. While counterparty default can happen presettlement and during settlement, counterparty risk typically applies to the risk of default prior to settlement. (LO 32.a)

Module Quiz 32.2

1. **D** Because Ondine currently has a negative mark-to-market value and the counterparty is defaulting, Ondine is able to cancel the transaction while it is "losing." Netting and close-out would require Ondine to make a payment because it would owe a net amount of $1 million. Collateralization is not relevant in this scenario. (LO 32.e)

2. **D** Mitigating counterparty risk often leads to the generation of other types of risk. In the case of central counterparties, systemic risk is created as counterparty risk has been centralized with a limited amount of groups. If one of these groups fails, a substantial shock may be experienced by the financial system as a whole. (LO 32.e)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Gregory, Chapter 6.

READING 33

NETTING, CLOSE-OUT, AND RELATED ASPECTS

Study Session 6

EXAM FOCUS

In this reading, we further discuss ways to mitigate counterparty risk and credit exposure. Specifically, we will address the different methods of reducing current and potential future credit exposure. These methods include termination features and netting and close-out features. For the exam, understand the advantages and disadvantages of netting and termination features. Also, be able to explain reset agreements, break clauses, walkaway clauses, and trade compression and how they are used.

MODULE 33.1: MITIGATING COUNTERPARTY RISK AND CREDIT EXPOSURE

ISDA Master Agreement

LO 33.a: Explain the purpose of an International Swaps and Derivatives Association (ISDA) master agreement.

The International Swaps and Derivatives Association (ISDA) Master Agreement standardizes over-the-counter (OTC) agreements to reduce legal uncertainty and mitigate credit risk. This is accomplished by creating a framework that specifies OTC agreement terms and conditions related to collateral, netting, and termination events. The Master Agreement can cover multiple transactions by forming a single legal contract with an indefinite term.

Netting and Close-Out Procedures

LO 33.b: Summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit

into the framework of the ISDA master agreement.

Netting and Close-Out Between Two Counterparties

Netting, often called set-off, generally refers to combining the cash flows from different contracts with a counterparty into a single net amount. This is referred to as **payment netting**, which acts to reduce settlement risk while enhancing operational efficiency. A related concept is **close-out netting**, which refers to the netting of contract values with a counterparty in the event of the counterparty's default. The concepts of both netting and close-out incorporate two related rights under a single contract: (1) the right to terminate contracts unilaterally (by only one side) under certain conditions (close-out) and (2) the right to offset (net) amounts due at termination into a single sum.

Before we examine close-out closer, it is important to discuss netting in more detail. Netting has enabled an explosive growth in credit exposures and notional values of trades, and it now covers most derivatives transactions. Institutions often have multiple trades with a counterparty, and these trades can constitute hedges whose values move in opposite directions, or they may constitute unwinds where a reverse trade of equal and opposite value has been executed with the same counterparty. Without netting, an entity's exposure of two equal and opposite trades is the positive mark-to-market exposure. For example, if an entity has two equal and opposite trades with a counterparty with mark-to-market values of +10 and –10, without netting the total exposure is +10. This means that if the counterparty defaults, the value of the two trades is not netted, with the surviving entity having to make a settlement under the negative mark-to-market trade, while unable to collect on the positive one. Therefore, without netting, overall exposure is additive as the sum of the positive mark-to-market values. With netting, exposures of trades are not additive, which significantly reduces risk.

Netting has several advantages and disadvantages:

- *Exposure reduction*: By offsetting exposures with parties managing net positions only, netting reduces risk and improves operational efficiency. Nevertheless, netted exposures can be volatile, which may result in difficulty in controlling exposure.
- *Unwinding positions*: If an entity wishes to exit a less liquid OTC trade with one counterparty by entering into an offsetting position with another counterparty, the entity will remove market risk; however, it will be exposed to counterparty and operational risk. Netting removes these risks through executing a reverse position with the initial counterparty, removing both market and counterparty risk. The downside is that the initial counterparty, knowing that the entity is looking to exit a trade, may impose less favorable terms for the offsetting transaction.
- *Multiple positions*: An entity can reduce counterparty risk, obtain favorable trade terms, and reduce collateral requirements by trading multiple positions with the same counterparty.
- *Stability*: Without netting, entities trading with insolvent or troubled counterparties would be motivated to cease trading and terminate existing contracts, exacerbating

the financial distress of the counterparty. With netting, this risk is significantly reduced, and an agreement with a troubled counterparty is more achievable.

Netting agreements (specifically close-out netting) are legal agreements that become effective in the event of a counterparty's bankruptcy. As mentioned, netting agreements are often governed by the ISDA Master Agreement, which serves to eliminate legal uncertainties and reduce counterparty risk under a single legal contract with an indefinite term. A single universal agreement also helps avoid problems that may arise from different treatments of bankruptcy in different jurisdictions. For example, ISDA has obtained legal opinions for the Master Agreement in most jurisdictions. Agreements often cover bilateral netting, which is used for OTC derivative and repo transactions, and balance sheet loans and deposits. When no legal agreement exists that allows netting, exposures do not offset each other and are considered additive.

Close-out and netting become advantageous in derivatives transactions following the default of a counterparty when cash flows cease because these rights allow an entity to execute new replacement contracts. It is clear then that close-out arrangements protect the solvent, or surviving, entity. Note that close-out differs from an **acceleration clause**, which allows the creditor to accelerate (i.e., make immediately due) future payments given a credit event, such as a ratings downgrade. In contrast to acceleration, **close-out clauses** allow all contracts between a solvent and insolvent entity to be terminated, which effectively cancels the contracts and creates a claim for compensation. If the solvent entity has a negative mark-to-market exposure (it owes the insolvent entity), then the full payment is made to the insolvent entity. If the mark-to-market exposure is positive, the solvent entity becomes a creditor for that amount and can terminate and replace the contracts with another entity.

Both acceleration and close-out clauses have been criticized for making a debtor's refinancing more difficult. Both clauses cause payment amounts to be immediately due and may speed up the financial distress of the insolvent entity. For this reason, courts may impose a stay (temporary suspension) on the agreements to allow for a short period of "time out" while maintaining the validity of the termination clauses.

Despite these criticisms, close-out clauses can be very advantageous to parties. Close-out limits the uncertainty in the value of an entity's position with an insolvent counterparty. Without close-out, an entity would have difficulty estimating to what degree positions offset each other because recovery of exposure is not known. With close-out, however, the solvent entity can fully re-hedge transactions with the insolvent entity while waiting to receive a claim. As a result, although the solvent entity may experience some risk loss, it would minimize market risk and trading uncertainty. In addition, close-out allows entities to freeze their exposures. Because these exposure amounts are known and will not fluctuate, the solvent entity can then better hedge this exposure.

Netting and Close-Out Between Multiple Counterparties

Up until this point, we have been discussing **bilateral netting**; that is, netting arrangements between two entities. Bilateral netting is important in reducing credit exposure; however, it is limited to two entities only. In reality, trades are often

structured in a way where an entity trades with multiple counterparties (known as **multilateral netting**). For example, Entity A can have exposure to B, Entity B has the same exposure to Entity C, and Entity C has an identical exposure to Entity A. The default of any of these entities would give rise to questions on how to allocate losses.

Under multilateral netting, netting arrangements would involve multiple counterparties to mitigate counterparty and operational risk. Typically, multilateral netting is achieved with a central entity, such as an exchange or clearinghouse, handling the netting process, including valuation, settlement, and collateralization. A disadvantage, however, is that this type of netting arrangement mutualizes counterparty risk and results in less incentive for entities to monitor each other's credit qualities. In addition, multilateral netting can enable redundant trading positions to accumulate in the system, resulting in higher operational costs (this risk is reduced by firms that use algorithms to detect and reduce redundant positions). Finally, multilateral netting requires trading disclosure, which may be disadvantageous to firms wishing to keep proprietary information confidential.

Netting Effectiveness

LO 33.c: Describe the effectiveness of netting in reducing credit exposure under various scenarios.

As we have previously discussed, netting can either reduce exposure to a counterparty or have no effect on exposure, but it can never increase it. We now look at netting in more detail, including the relationship between netting and exposure.

A trading instrument will have a beneficial effect on netting if it can have a negative mark-to-market (MtM) value during its life. For instruments whose MtM value can only be positive during their life, the effect on netting will not be as beneficial. Instruments with only positive MtM values include options with up-front premiums such as equity options, as well as swaptions, caps and floors, and FX options. Other instruments can have negative MtM value during their life; however, there is a greater likelihood that MtM will be positive. These instruments include long options without up-front premiums, certain interest rate swaps, certain FX forwards, cross-currency swaps, off-market instruments, and wrong-way instruments.

Despite these instruments having either only positive or mostly positive MtM values, it may still be worthwhile for an entity to include them under a netting agreement for the following reasons:

- Future trades with negative MtM values could offset the positive MtM of these instruments.
- Inclusion of all trades is necessary for effective collateralization.
- Netting is beneficial as it ensures that if these positions need to be unwound in the future and an offsetting (mirror) trade is required, there will be no residual counterparty risk.

Termination Features

LO 33.d: Describe the mechanics of termination provisions and trade compressions and explain their advantages and disadvantages.

LO 33.f: Identify and describe termination events and discuss their potential effects on parties to a transaction.

Termination events allow institutions to terminate a trade before their counterparties become bankrupt. A **reset agreement** readjusts parameters for trades that are heavily in the money by resetting the trade to be at the money. Reset dates are typically linked with payment dates, but they could also be triggered after a certain market value is breached. As an example, consider a resettable cross-currency swap. With this trade, the MtM value of the swap is exchanged at each reset date. In addition, the foreign exchange rate, which influences the swap's MtM value, is reset to the current spot rate. This reset will end up changing the notional amount for one leg of the swap.

Additional termination events (ATEs), which are sometimes referred to as break clauses, are another form of a termination event, which allow an institution to terminate a trade if the creditworthiness of their counterparty declines to the point of bankruptcy. More specifically, a **break clause** (also called a liquidity put or early termination option) allows a party to terminate a transaction at specified future dates at its replacement value. Break clauses are often bilateral, allowing either party to terminate a transaction, and are useful in providing an option to terminate transactions —particularly long-dated trades—without cost when the quality of the counterparty declines. Events to trigger a break clause generally fall into three categories:

- Mandatory. The transaction will terminate at the date of the break clause.
- Optional. One or both counterparties have the option to terminate the transaction at the pre-specified date.
- Trigger-based. A trigger, like a ratings downgrade, must occur before the break clause may be exercised.

Despite their advantages, break clauses have not been highly popular. One explanation is that break clauses, in effect, represent a discrete form of collateralization; however, collateralization can be better achieved by the continuous posting of collateral. Another explanation is known as "banker's paradox," which implies that for a break clause to be truly useful, it should be exercised early on, prior to the substantial decline in a counterparty's credit quality. Entities, however, typically avoid early exercise to preserve their good relationships with counterparties.

Walkaway clauses allow an entity to benefit from the default of a counterparty. Specifically, under these clauses an entity can walk away from, or avoid, its net liabilities to a counterparty that is in default, while still being able to claim in the event of a positive MtM exposure. Walkaway clauses were popular prior to 1992, but they have been less common since the 1992 ISDA Master Agreement. They have also been criticized for creating additional costs for a counterparty in the event of a default, for creating moral hazard, and, because a walkaway feature may already be priced in a

transaction, hiding some of the risks in a transaction. For these reasons, these clauses should be ultimately avoided.

LO 33.e: Provide examples of trade compression of derivative positions, calculate net notional exposure amount, and identify the party holding the net contract position in a trade compression.

As mentioned, multilateral netting is achieved with a central entity, such as an exchange or clearinghouse, handling the netting process—including valuation, settlement, and collateralization. An approach for using multilateral netting without the need for a membership organization is **trade compression**. Because portfolios often have redundancies among trades with multiple counterparties, compression aims to reduce the gross notional amount and the number of trades (e.g., OTC derivatives transactions). Thus, trade compression can reduce net exposure without the need to change an institution's overall risk profile.

Trade compression requires participants to submit applicable trades for compression along with their desired risk tolerance. The submitted trades are then matched to each counterparty and netted into a single contract. For example, consider an institution with three credit default swap (CDS) contracts for the same reference entity and maturity, but with different counterparties. In this case, the three trades can be compressed into a single net contract by netting out the long and short contracts and using the weighted average of the three contract coupons as the net contract coupon. Figure 33.1 illustrates trade compression for single-name CDS contracts.

Figure 33.1: Trade Compression Example

Reference Entity	Notional	Position	Maturity	Coupon	Counterparty
XYZ index	200	Long	March 20, 2025	100	Counterparty X
XYZ index	100	Short	March 20, 2025	100	Counterparty Y
XYZ index	75	Short	March 20, 2025	100	Counterparty Z
Net contract	**25**	**Long**	**March 20, 2025**	**100**	**Counterparty X**

In this example, Counterparty X holds the net contract position with a notional exposure amount of 25. Note that trade compression services, such as TriOptima, help reduce OTC derivatives exposures for various products, such as interest rates, commodities, and credit derivatives. In addition, recent changes to the CDS market, such as standard coupons and maturity dates, also help promote the benefits of trade compression.

MODULE QUIZ 33.1

1. Riggs Resources, LLC, (Riggs) is a commodity trading firm. Riggs has numerous trades outstanding with several counterparties; however, it is concerned with presettlement risk. In order to reduce presettlement risk (the risk that Riggs's counterparties would default before settlement), it would be most beneficial for Riggs to:

   A. have payment netting.
   B. have close-out netting.

C. analyze potential losses as the sum of exposures.
D. have netting but not set-off.

2. Entity XYZ is netting its trades with Entity ABC. Which of the following techniques best describe this type of netting arrangement?
   A. Multilateral netting.
   B. Bilateral netting.
   C. Close-out netting.
   D. Additive exposure netting.

3. Assume the following current MtM values for five different transactions for Entity ABC: +5, −4, +2, +3, and −6. What is the total exposure with and without netting, respectively?
   A. 0, 10.
   B. 20, 10.
   C. 10, 0.
   D. 10, 20.

4. Which of the following trading instruments would have the most beneficial effect on netting?
   A. Options with up-front premiums.
   B. Equity options.
   C. FX options.
   D. Futures.

5. Leverage, Inc., an investment bank, has numerous credit default swaps with XYZ Corp. Leverage has established a break clause with XYZ Corp. to reduce risk. The break clause is trigger-based and may be exercised once the trigger is satisfied. The CEO of Leverage is concerned about a banker's paradox. Which of the following statements best describe the CEO's concern?
   A. To be effective, the break clause option should not be used too early.
   B. The weak firm often recovers after the use of the break clause.
   C. The break clause option is used too late, and the weak firm gets weaker.
   D. The break clause option is used too early, and is unlikely to avoid systemic risk issues.

KEY CONCEPTS

LO 33.a

Standardization of terms of OTC derivatives through the ISDA Master Agreement is a key way to mitigate credit risk to improve liquidity and reduce transaction costs.

LO 33.b

Netting involves combining the cash flows from different contracts with a counterparty into a single net amount (payment netting). Close-out netting refers to netting contract values with a counterparty if the counterparty defaults. Without netting, exposures are additive; with netting, exposures of trades are not additive.

Bilateral netting is limited to two entities only. Multilateral netting involves netting between multiple parties, usually with a central entity, such as an exchange or clearinghouse, handling the netting process.

LO 33.c

Netting arrangements are beneficial as long as trading instruments can have negative mark-to-market (MtM) values during their life. Netting for trades with the possibility of only positive exposures is generally not beneficial, although benefits can arise if future trades with negative MtM values could offset the positive MtM of these instruments.

LO 33.d

Walkaway clauses allow an entity to walk away from its liabilities to a counterparty that is in default, while still being able to make a claim on its own exposure.

LO 33.e

Trade compression reduces net exposure without the need to change the overall risk profile.

LO 33.f

Termination events allow institutions to terminate a trade before their counterparties become bankrupt. A break clause allows a party to terminate a trade at specified future dates at replacement values.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 33.1

1. **B** To minimize presettlement risk, Riggs should have close-out netting. Under close-out, contracts between solvent and insolvent counterparties are terminated and netted.

   Payment netting would reduce settlement and operational risk, but not presettlement risk. Netting also means individual positive exposures are nonadditive. The terms netting and set-off are synonymous. (LO 33.b)

2. **B** Bilateral netting is a netting arrangement between two entities and is limited to two entities. Trades with multiple counterparties is known as multilateral netting. Close-out netting refers to netting contract values with a counterparty if the counterparty defaults. (LO 33.b)

3. **A** The total exposure with netting is 0 (5 − 4 + 2 + 3 − 6 = 0), and the total exposure without netting is 10 (5 + 2 + 3 = 10). (LO 33.b)

4. **D** A trading instrument will have a beneficial effect on netting if it can have a negative mark-to-market (MtM) value during its life. For instruments whose MtM value can only be positive during their life, the effect on netting will not be as beneficial. Instruments with only positive MtM values include options with up-front premiums such as equity options, as well as swaptions, caps and floors, and FX options. Futures can have negative MtM values. (LO 33.c)

5. **C** A break clause (also called a liquidity put or early termination option) allows a party to terminate a transaction at specified future dates at its replacement value. Despite their advantages, break clauses have not been highly popular. One explanation is known as banker's paradox, which implies that for a break clause to be truly useful, it should be exercised early on, prior to the substantial decline in a counterparty's credit quality. Entities, however, typically avoid early exercise to preserve their good relationships with counterparties. (LO 33.f)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Gregory, Chapter 7.

READING 34

MARGIN (COLLATERAL) AND SETTLEMENT

Study Session 6

EXAM FOCUS

This reading examines collateral and introduces the types of collateral, the features of a collateralization agreement and a credit support annex (one-way and two-way), and the reconciliation of collateral disputes. For the exam, be familiar with the key parameters associated with collateral (e.g., threshold, initial margin, and minimum transfer amount). In addition, understand the risks associated with collateralization, focusing on market risk, operational risk, and funding liquidity risk.

MODULE 34.1: COLLATERAL

Collateral Management

LO 34.a: Describe the rationale for collateral management.

LO 34.b: Describe the terms of a collateral agreement and features of a credit support annex (CSA) within the ISDA Master Agreement including threshold, initial margin, minimum transfer amount and rounding, haircuts, credit quality, and credit support amount.

The concept behind collateralization is straightforward. When two parties execute certain trades (e.g., OTC forwards, swaps), one will have a negative MtM (mark-to-market) exposure, and the other party will have a positive MtM exposure at any given time. The party with the negative exposure will then post collateral in the form of cash or securities to the party with the positive exposure. In essence, *collateral is an asset supporting a risk in a legally enforceable way*. **Collateral management** is often bilateral, where either side to a transaction is required to post or return collateral to the side with the positive exposure.

Firms can manage credit exposures and mitigate counterparty credit risk by either limiting the notional value of trades with counterparties or offsetting trades that limit

exposure though netting. There are essentially four motivations for managing collateral: (1) reduce credit exposure to enable more trading, (2) have the ability to trade with a counterparty (e.g., restrictions on credit ratings may preclude an entity from trading on an uncollateralized basis), (3) reduce capital requirements, and (4) allow for more competitive pricing of counterparty risk.

Collateral management has evolved over the last few decades from having no legal standards to being highly standardized through the introduction of ISDA documentation in 1994. The purpose of a **credit support annex (CSA)** incorporated into an ISDA Master Agreement is to allow the parties to the agreement to mitigate credit risk through the posting of collateral. Because collateral can vary greatly in terms of amount, liquidity, and risk levels (as well as many other elements), a CSA is created to govern issues such as collateral eligibility, interest rate payments, timing and mechanics associated with transfers, posted collateral calculations, haircuts to collateral securities (if applicable), substitutions of collateral, timing and methods for valuation, reuse of collateral, handling disputes, and collateral changes that may be triggered by various events. In order to work as intended, CSAs must define all collateralization parameters and account for any scenarios that may impact both the counterparties and the collateral they are posting.

Parameters established with CSAs (and collateralized agreements in general) include the following:

- **Threshold**. Collateral will be posted when the level of MtM exposure exceeds this threshold level.
- **Initial margin** (also known as **independent amount** in bilateral markets). The amount of extra collateral that is required independent of the level of exposure.
- **Minimum transfer amount**. The minimum amount of collateral that can be called at a given time.
- **Rounding**. Collateral calls or collateral returns may be rounded to specific sizes to avoid working with inconvenient quantities.
- **Haircut**. This reduces the value of collateral to account for the possibility that its price may fall between the previous collateral call and a counterparty default.
- **Credit quality**. As counterparty credit quality declines, the importance of collateral increases.
- **Credit support amount**. The amount of collateral that may be called (by either counterparty) at a certain point in time.

PROFESSOR'S NOTE

The terms of a collateral agreement as well as descriptions of threshold, initial margin, minimum transfer amount, rounding, haircuts, and credit quality will be addressed in LO 34.g when we explain the features of a collateralization agreement.

Valuation Agents

LO 34.d: Describe the role of a valuation agent.

The valuation agent is responsible for calling for the delivery of collateral and handles all calculations. The valuation agent's role is to calculate (1) credit exposure, (2) market values, (3) credit support amounts, and (4) the delivery or return of collateral. Larger entities often insist on being valuation agents when dealing with smaller counterparties. When the size difference between counterparties is small, both counterparties may be valuation agents. In this case, each entity would call for collateral when they have positive exposure; however, this could lead to disputes and delays in processing collateral movements. One remedy is to use a third-party valuation agent that would handle the collateral process, processing collateral substitutions, resolving disputes, and producing daily valuation reports.

Collateral Agreements and Types of Collateral

LO 34.e: Describe the mechanics of collateral and the types of collateral that are typically used.

The process of collateralization is typically done through legal documents under which parties negotiate collateral supporting documents that state the terms and conditions of the process. Collateral agreements should quantify parameters and specify the currency, type of agreement (one-way or two-way), what collateral is eligible, timing regarding delivery and margin call frequency, and interest rates for cash collateral. Trades between counterparties are then marked-to-market (MtM) on an ongoing basis (typically daily), and valuations including netting are determined. The party with the negative MtM exposure then delivers collateral to the other side of the transaction, and the collateral position is updated.

There are many types of collateral used, depending on the riskiness of the credit exposures. Collateral can include cash, government and government agency securities, mortgage-backed securities, corporate bonds and commercial paper, letters of credit, and equity. The most common type of collateral is cash; however, during extreme market events, the supply of cash collateral can be limited. Other collateral types, including agency securities, are often preferred for liquidity; however, recent market events have led to questioning the true riskiness of these securities. In addition, noncash collateral may give rise to problems with rehypothecation (defined later in this reading) and create price uncertainty.

Collateral Coverage, Disputes, and Resolutions

LO 34.f: Explain the process for the reconciliation of collateral disputes.

To mitigate risk, it is generally preferred to include the maximum number of trades in collateral agreements. However, if even a single trade cannot be properly valued, it can

complicate collateral calls and may lead to collateral disputes. If trades include potentially problematic assets, it may be optimal to only focus on a subset of trades that make up the majority of credit exposure and leave out asset classes that are hard to value either due to complexity (e.g., exotic options) or illiquidity (e.g., credit derivatives). Global considerations are also important, especially as counterparties trade with each other over many time zones and geographical locations. It may be optimal to handle trades separately with regions that are problematic and make up only a small portion of trades. Finally, if an entity expects one of its counterparties to have difficulty valuing certain trades or assets, it may be preferred to leave those trades uncollateralized rather than face potential and frequent disputes. Given that collateral agreements typically require that undisputed amounts be transferred immediately, it is generally advantageous to collateralize the majority of products.

If disputes do arise, they can relate to the trade population, trade valuation, netting rules, market data and market closing time, and valuing collateral that was previously posted. If the disputed amount or valuation difference is small, counterparties may simply split the difference. If the disputes involve larger differences, the exposure will remain uncollateralized until the dispute is resolved. Disputes include the following steps: (1) the disputing party notifies the counterparty of its intent to dispute the exposure by the end of the day following the collateral call; (2) all undisputed amounts are transferred, and the reason for the dispute is identified; and (3) for unresolved disputes, the parties will request quotes from several market makers (usually four) for the MtM value.

Reconciling trades minimizes the chance of disputes. Parties may also find it beneficial to perform dummy (practice) reconciliations prior to trading and periodic reconciliations during trading (weekly or monthly) to preempt future disputes.

MODULE QUIZ 34.1

1. Which of the following features is least likely a benefit of collateralization?
   A. Reduces capital requirements.
   B. Allows for more competitive pricing of counterparty risk.
   C. Reduces market, operational, and liquidity risk.
   D. Reduces credit exposure.

2. Which of the following statements is least accurate regarding a credit support annex (CSA) and/or an ISDA Master Agreement?
   A. ISDA Master Agreements help standardize collateral management.
   B. CSAs must define all collateralization parameters in order to work as intended.
   C. Compared to the ISDA Master Agreement, CSAs were first to establish collateral standards.

D. CSAs are incorporated into an ISDA Master Agreement.

MODULE 34.2: COLLATERAL AGREEMENTS

Collateral Agreement Features

LO 34.g: Explain the features of a collateralization agreement.

Collateral agreements are typically negotiated prior to any trading, and they are often updated prior to an increase in trading. Parameters must be clearly defined, and parties must balance the work involved in calling and returning collateral with the benefits of risk mitigation.

Terms of a collateral agreement may be linked to the credit quality of counterparties in order to minimize operational workload while maintaining the ability to tighten collateral terms when a party's credit quality declines. Counterparties most commonly link a tightening of collateral terms to changes in credit rating (e.g., to a downgrade in rating to below investment grade). While this approach is easy to set up, it can lead to issues by requiring the downgraded counterparty to post collateral exactly at a time when it is experiencing credit issues. This can lead to a "death spiral" of the affected counterparty, as the counterparty faces multiple collateral calls. As a result, it may be preferable to link collateral terms not to the credit rating of entities, but to credit spreads, the market value of equity, or net asset values.

Margin calls should be done at least daily. Products like repos and swaps that are cleared via central counterparties most often have intraday margining. While longer margin frequencies likely reduce operational workloads, daily margining has, more or less, become the market norm.

Threshold in margining refers to the level of exposure below which collateral will not be called. As a result, threshold represents the level of uncollateralized exposure, and only the incremental amount above the threshold would be collateralized. Thresholds generally aim to reduce the operational burden of calling collateral too frequently. A threshold of zero means any exposure is collateralized, while a threshold of infinity means all exposure is uncollateralized. Thresholds are most often linked to credit ratings in a tiered manner, with lower credit ratings corresponding to lower or zero threshold amounts.

Initial margin is the collateral amount that is posted upfront and is "independent" of any subsequent collateralization. It is often used to mitigate the widening of credit spreads or declines in equity values. Initial margin is typically required by stronger credit quality counterparties or by the counterparty more likely to have positive exposures and represents a level of **overcollateralization**. Initial margins are also typically linked to the credit rating of counterparties in a tiered manner; however, as opposed to thresholds, the level of initial margin *increases* with lower ratings. Initial margins can be thought of as converting counterparty risk into gap risk, ensuring that the less risky counterparty always remains overcollateralized by this amount without incurring losses, even when the risky counterparty defaults. Initial margins should,

therefore, be large enough to minimize the gap from large value movements of trades should the risky counterparty default.

A **minimum transfer amount** represents the smallest amount of collateral that can be transferred. A minimum transfer amount is used to reduce the operational workload of frequent transfers for small amounts of collateral, which must be balanced against the benefits of risk mitigation. It is important to note that the threshold and minimum transfer amount are additive; that is, exposure must exceed the sum of *both* before a collateral call can be made. Minimum transfer amounts are also typically tied to credit ratings, with higher ratings corresponding to higher amounts.

Collateral amounts typically use **rounding** (e.g., to the nearest thousand) to avoid transferring very small amounts during collateral calls or returns.

A **haircut** is essentially a discount to the value of posted collateral. In other words, a haircut of x% means that for every unit of collateral posted, only (1 – x)% of credit will be given. This credit is also referred to as valuation percentage. Cash typically has a haircut of 0% and a valuation of 100%, while riskier securities have higher haircut percentages and lower corresponding valuation percentages.

For example, if a particular sovereign bond has a haircut of 2% and a collateral call of $100,000 is made, only 98% of the collateral's value is credited for collateral purposes. That is, in order to satisfy a $100,000 collateral call, $102,041 ($100,000 / 0.98) of the sovereign bond must be posted (or $100,000 in cash).

It is easy to see that riskier securities have greater haircuts to account for their volatility, which may lead to a decline in their value. In the order of increasing riskiness and higher haircuts, cash typically has no haircuts, followed by high-quality government bonds, AAA-rated corporate bonds, structured notes or products, and, finally, equities and commodities. Key factors to consider when assessing haircuts are time to liquidate collateral, volatility of the collateral's underlying market, and the default risk, maturity, and liquidity of the security. Assessing haircuts will often depend on current market conditions using sophisticated value at risk (VaR) calculations.

Entities usually pay interest, coupons, dividends, and other cash flows to counterparties posting collateral as long as the counterparty is not in default. Interest on cash collateral is paid at an overnight market rate. During times of high volatility and illiquid markets, cash collateral is generally preferred, and entities may pay higher-than-market interest rates as an incentive to the entity posting collateral.

LO 34.i: Explain aspects of collateral including funding, rehypothecation, and segregation.

We will now look at substitution, reuse, rehypothecation, and segregation of collateral. Counterparties sometimes require that the original posted collateral be returned to them for various reasons, including meeting certain delivery commitments. In this case, they can make a **substitution** request by posting an equivalent value of some other eligible collateral. Substitution requests cannot be refused by the other party if the

substituted collateral meets all eligibility criteria. Noncash collateral may also be sold, used in repo transactions, or rehypothecated.

Rehypothecation refers to transferring posted collateral to other counterparties as collateral. While widespread, rehypothecation carries two related risks. Consider a scenario where Party A pledges collateral to Party B; Party B rehypothecates this collateral to Party C. If Party C defaults, then Party B will not only have a loss from not receiving the collateral from Party C, it will also have a liability to Party A for not returning its collateral. The practice of rehypothecation was relatively widespread prior to the 2007–2009 credit crisis; however, it has been significantly less popular following the crisis. Parties now increasingly prefer cash collateral.

In the event of default, there is a risk that collateral may not be retrieved even when it is not rehypothecated. If the counterparty receiving the collateral becomes insolvent, for example, **segregation** of collateral can be used to reduce counterparty risk by legally protecting the posted collateral. This practice establishes legal actions that will return all collateral that is not required. Thus, segregation works contrary to rehypothecation. Note, however, that segregation may result in funding problems when replacing collateral that could have been rehypothecated.

CSA Agreements

LO 34.h: Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality.

There may be instances when CSAs are not used. Institutions may be unable or unwilling to post collateral. This may be because their credit quality is far superior to their counterparty or they cannot commit to the operational and liquidity requirements that arise from committing to a CSA.

A **two-way CSA** is often established when two counterparties are relatively similar, as it will be beneficial to both parties involved. It is important to note that the two sides may not be treated equally, as certain key parameters (like threshold and initial margin) may differ depending on the respective risk levels of each party.

A **one-way CSA** differs from a two-way CSA in that the former only requires that one counterparty post collateral (either immediately or after a specific event, such as a ratings downgrade). As a result, the CSA will be beneficial to the receiver of the collateral and at the same time will present additional risk for the counterparty posting the collateral. These types of CSAs are established when two counterparties are significantly different in size, risk levels, et cetera.

The terms of a collateral agreement are usually linked to the credit quality of the counterparties in a transaction. This is beneficial when a counterparty's credit quality is strong because it minimizes operational workload. However, it is also beneficial when a counterparty's credit quality is weak as it allows the other party to enforce collateralization terms triggered by a quality downgrade. Although credit ratings are the most common quality linked, others include market value of equity, net asset value, and traded credit spread. The benefits of linking to credit ratings must be weighed

against the costs associated with the requirement of collateral when a ratings downgrade occurs.

CSA Calculations

LO 34.c: Calculate the credit support amount (margin) under various scenarios.

ISDA documentation specifies that, at any point in time, the credit support amount is equal to the amount of the requested margin. This amount will not be equal to the value of the portfolio due to parameters such as thresholds, initial margins, and minimum transfer amounts.

Assume a counterparty is only receiving the margin amount. In this case, the credit support amount (margin) calculation when only considering the threshold and initial margin is:

$$\max(\text{value} - K_A, 0) + IM_A$$

where:
value = current value of applicable transactions
K_A = threshold (fixed amount)
IM_A = initial margin (dynamic amount)

This equation shows that thresholds and initial margins work in opposite directions. As a result, it is typically the case that when initial margins are present, the threshold will be set to zero.

When considering both counterparties, the equation for computing the credit support amount (for variation margin) is:

$$\max(\text{value} - K_A, 0) - \max(-\text{value} - K_B, 0) - \text{CSB}$$

where:
K_B = threshold for the counterparty generating the margin calculation
CSB = credit support balance (margin previously held)

If this equation results in a positive amount, then margin can be called; if it results in a negative amount, then margin is required to be posted. These conditions hold as long as the margin amount is greater than the minimum transfer amount.

Note that initial margin is not a factor in the previous calculation. It is typically the case that the credit support amount captures variation margin, but not initial margin. The initial margin will be computed independently and, thus, it is sometimes referred to as the independent amount. In the event that both counterparties post initial margin, those amounts will not be netted, and initial margins will be paid separately. Figures 34.1 and 34.2 illustrate example margin calculations without and with initial margins, respectively.

Figure 34.1: Margin Calculation Example (Without Initial Margin)

	Time 1	Time 2
Portfolio value	250	225
Threshold	100	100
Credit support balance	0	150
Credit support amount	150	–25

At Time 1, the portfolio value is not fully collateralized. At Time 2, the portfolio is uncollateralized by 75 (= 225 – 150), but the credit support amount is negative 25, which is the amount of margin that needs to be posted up to the threshold amount of 100.

Figure 34.2: Margin Calculation Example (With Initial Margin)

	Time 1	Time 2
Portfolio value	250	275
Threshold (set to zero)	0	0
Credit support balance	0	250
Credit support amount	250	25
Initial margin (independent amount)	40	35

At Time 1, the addition of initial margin means that the portfolio is overcollateralized. At Time 2, the portfolio value increase results in a margin deficit of 25, but this move is within the initial margin amount. Note that despite the increase in variation margin, the initial margin is independent and will not be netted with the increase.

Collateral Agreement Risks

LO 34.j: Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization.

Collateralization may improve asset recovery in the event of a counterparty default, but it should be viewed as a supplement to, not a replacement for, ongoing due diligence review of credit quality and exposure. Use of collateral may be viewed as a double-edged sword. When managed properly, it can mitigate risks, but when managed poorly, it may well give rise to additional risks. Collateral agreements could potentially cause the following risks.

Market Risk

Market risk relates to the degree of market movements that have occurred since the last posting of collateral. It is relatively small compared to the risk of an uncollateralized situation, but market risk is a challenge to hedge and to quantify.

Even though collateral is in place to mitigate counterparty risk, there will always be some residual risk due to parameters such as minimum transfer amounts and thresholds that delay the collateral process. In addition, even when collateral is called, there will be a normal delay in sending/receiving the collateral. This delay is

represented as the margin period of risk, which is the effective time between a collateral call and the receipt of the collateral.

Operational Risk

Potential pitfalls in the handling of collateral include missed collateral calls, failed deliveries, computer error, human error, and fraud. Proper controls must be in place to reduce the likelihood of the occurrence of any one of the foregoing items. Examples of proper controls would be the existence of accurate and enforceable legal agreements, robust IT systems capable of automating many steps in the process, timely and accurate valuation of the collateral, current information on initial margins, minimum transfer amounts, rounding, a requirement that collateral types and currencies must be available for each counterparty, and careful observation of the failure to deliver collateral.

Liquidity and Liquidation Risk

Transaction costs may result when having to liquidate collateral to mitigate counterparty risk. These are often in the form of a bid-ask spread or selling costs. Liquidating a security in an amount that is large relative to its typical trading volume may negatively impact its price, leading to a substantial loss. The alternative is to liquidate a position slowly. With this approach, the counterparty is exposed to market volatility during the period of liquidation. Additional considerations regarding liquidity risk include:

- How large is the market capitalization of the issue posted as collateral?
- Is there a link between the value of the collateral and the counterparty's credit quality? This would be an example of wrong-way risk (when credit exposure and default risk both increase at the same time).
- Would the liquidity of the collateral change due to a default by the counterparty?

Funding Liquidity Risk

Funding liquidity risk refers to the ability of an institution to settle its obligations quickly when they become due, which results from the funding needs established in a CSA. For various reasons, collateral agreements are not in place for many OTC derivatives transactions. When a counterparty does not have the operational capacity or liquidity to handle frequent collateral calls (required under a CSA), the counterparty will be vulnerable to funding implications. This risk is relatively small when markets are liquid and funding costs are low. However, when markets are illiquid, the risks become higher because funding costs can increase considerably.

Default Risk

The default of a security posted as collateral will lower its value (when the loss in value is unlikely to be covered by a haircut). Cash or high-quality fixed-income securities are usually the preferred type of collateral. Should the collateral's credit rating fall below what the collateral agreement specifies, then it would need to be replaced. Poor collateral may fail to mitigate counterparty risk.

Foreign Exchange Risk

Foreign exchange risk occurs when counterparties have different currencies. Collateral carrying foreign exchange risk can be hedged in spot and forward markets. The process must be done carefully due to the dynamic and changing value of the collateral.

Regulatory Requirements

LO 34.k: Describe the various regulatory capital requirements.

Non-clearable over-the-counter (OTC) transactions require banks to hold higher capital requirements compared to standardized OTC transactions. In 2011, the G20 established bilateral collateral requirements for non-clearable OTC derivatives. These regulatory requirements cover both variation and initial margins with the goal to minimize systemic risk and reduce potential regulatory arbitrage between clearable and non-clearable OTC transactions. However, these newer rules require additional collateralization, which forces banks to either find additional funding sources or leave the OTC derivatives market all together. In addition, in a stressed market, funding liquidity risk will most likely increase.

Covered entities, which are financial and systemically important non-financial entities, are required to exchange both variation and initial margin. Variation margin must: (1) be exchanged frequently, (2) use full collateral, (3) not exceed $650,000, and (4) be posted in its entirety for any transactions after implementation. Initial margin should: (1) be highly liquid, (2) be exchanged without netting, (3) be protected by bankruptcy, (4) be based on extreme but possible portfolio movements, (5) use a 10-day time horizon, (6) be based on regulatory tables or internal models, and (7) follow a phased-in implementation.

It was also established that variation margin and initial margin be segregated. In case of any disagreements, strong resolutions should be set. Covered counterparties will most likely agree to new CSAs. These new or updated CSAs will address the following features: (1) thresholds, (2) minimum transfer amounts, (3) eligibility of collateral, (4) haircuts, (5) initial margin calculations, (6) deliveries and schedules, (7) resolutions for disputes, and (8) segregation approaches.

MODULE QUIZ 34.2

1. Collateral agreements could potentially create multiple risks, including liquidity and liquidation risks. Which of the following is most accurate regarding liquidity and liquidation risk?
   A. Liquidation risk occurs when the amount of a security sold is large relative to its outstanding volume, which may affect the price of that security.
   B. Liquidity risk must be hedged in spot and forward markets.
   C. Liquidation risk embodies a transaction cost when collateral is liquidated in accordance with initial margin.
   D. Liquidity risk occurs when there are potential pitfalls in the handling of collateral, including human error.

2. When dealing with a hedge fund, a bank would most likely negotiate a:

A. one-way agreement in the bank's favor given the bank's stronger credit rating.
B. one-way agreement in the bank's favor agreeing to post collateral to the hedge fund.
C. two-way agreement given the relatively small difference in credit quality between the two entities.
D. two-way agreement where both parties agree to post collateral.

3. Assume a sovereign bond has a haircut of 5% and is used for a collateral call of $100,000. What amount is credited if a $100,000 bond is submitted, and what amount of bond is needed for $100,000 to be credited, respectively?
A. $100,000; $106,263.
B. $95,000; $100,000.
C. $95,000; $105,263.
D. $105,263; $95,000.

KEY CONCEPTS

LO 34.a

Collateral is an asset supporting a risk in a legally enforceable way. Collateral management is often bilateral, where either side to a transaction is required to post or return collateral to the side with the positive exposure.

LO 34.b

A credit support annex (CSA) allows parties to mitigate credit risk through the posting of collateral. The CSA provides governance on many issues related to the collateral itself, including what may be used, when and how it should be valued and transferred, and any changes that must be made upon the occurrence of certain events. A CSA will also define key parameters such as the threshold, minimum transfer amount, and initial margin.

LO 34.c

The credit support amount (for variation margin) is computed as:

$$\max(\text{value} - K_A, 0) - \max(-\text{value} - K_B, 0) - \text{CSB}$$

where:
K_A = threshold for Counterparty A
K_B = threshold for Counterparty B
CSB = credit support balance (margin previously held)

If this equation results in a positive amount, then margin can be called; if it results in a negative amount, then margin is required to be posted (up to the threshold amount). The credit support amount captures variation margin, but not initial margin, which is computed independently.

LO 34.d

The role of the valuation agent is to call for the delivery of collateral and handle any collateral-related calculations, including credit exposure, market values, credit support amounts, and the delivery/return of collateral. One or both parties to an agreement may be the valuation agent, or alternatively, a third-party agent may be used.

LO 34.e

Collateralization involves the party with the negative exposure posting collateral in the form of cash or securities to the party with the positive exposure. Collateral can include cash, government and government agency securities, mortgage-backed securities, corporate bonds and commercial paper, letters of credit, and equity. The most common type of collateral is cash.

LO 34.f

Collateral disputes may arise due to the valuation and population of trades, market data and market closing time, netting rules, and valuing collateral previously posted. Managing disputes include the following steps: (1) the disputing party notifies the counterparty of its intent to dispute the exposure by the end of the day following the collateral call; (2) all undisputed amounts are transferred and the reason for the dispute is identified; and (3) for unresolved disputes, the parties will request quotes from several market makers (usually four) for the MtM value. Reconciling trades on a regular basis can minimize potential disputes.

LO 34.g

Threshold is the level of exposure below which collateral will not be called and represents the level of uncollateralized exposure.

Initial margin is the collateral amount that is posted upfront and is independent of any subsequent collateralization. It represents a level of overcollateralization and can be thought of as converting counterparty risk into gap risk to always maintain an overcollateralized position by the stronger credit quality party.

A minimum transfer amount represents the smallest amount of collateral that can be transferred and is used to reduce operational workload. The threshold and minimum transfer amounts are additive.

A haircut is a discount to the value of posted collateral, with cash having the lowest discount (highest credit given). The riskier the security, the higher the haircut and the lower the credit given.

Substitution refers to posting an equivalent value of other eligible collateral. Rehypothecation refers to transferring posted collateral to other counterparties as collateral.

LO 34.h

A one-way CSA requires one counterparty to post collateral, while a two-way CSA requires both sides to post collateral. For a two-way CSA, certain key parameters may differ if the parties' have different risk levels.

Collateral agreements are often linked to the credit quality of the counterparties in a transaction, in particular credit ratings. While this linking can be beneficial to one party if the other party's credit rating declines, there are costs associated with requiring collateral when a ratings downgrade occurs.

LO 34.i

Substitution refers to posting an equivalent value of other eligible collateral. Rehypothecation refers to transferring posted collateral to other counterparties as collateral. Segregation refers to legally protecting posted collateral.

LO 34.j

Key risks involved as a result of entering into a collateral agreement include the following: market risk (unfavorable market movements since the last collateral posting), operational risk (operational issues in the handling of collateral transactions), liquidity and liquidation risk (the ability to liquidate collateral without an unexpected or substantial loss in value), and funding liquidity risk (the ability to meet funding obligations as they come due).

LO 34.k

Non-clearable OTC transactions require banks to hold higher capital requirements. In 2011, the G20 established bilateral collateral requirements for non-clearable OTC derivatives. These regulatory requirements cover both variation and initial margins with the goal to minimize systemic risk and reduce potential regulatory arbitrage between clearable and non-clearable OTC transactions.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 34.1

1. **C** Collateralizing trades reduces credit exposure (credit risk) and capital requirements, and allows for more competitive pricing of counterparty risk. However, collateralization also creates other risks including market risk (negative equity leaving exposures partially or fully uncollateralized), operational risk (legal obstacles to take possession of collateral), and liquidity risk (difficulty in selling collateral at a fair market value). (LO 34.a)

2. **C** The purpose of a credit support annex (CSA) incorporated into an ISDA Master Agreement is to allow the parties to the agreement to mitigate credit risk through the posting of collateral. A CSA is created to govern issues such as collateral eligibility, interest rate payments, timing and mechanics associated with transfers, posted collateral calculations, haircuts to collateral securities (if applicable), substitutions of collateral, timing and methods for valuation, reuse of collateral, handling disputes, and collateral changes that may be triggered by various events. In order to work as they are intended to work, CSAs must define all collateralization parameters and account for any scenarios that may impact both the counterparties and the collateral they are posting. (LO 34.b)

Module Quiz 34.2

1. **A** Liquidating a security in an amount that is large relative to its typical trading volume may negatively impact its price, leading to a substantial loss. (LO 34.i)

2. **A** The bank would most likely negotiate a one-way agreement in its own favor given the higher credit quality of the bank. This type of negotiation is typical when there are large differences in credit quality between two entities. (LO 34.h)

3. **C** A haircut is essentially a discount to the value of posted collateral. In other words, a haircut of x% means that for every unit of collateral posted, only (1 − x)% of credit will be given. This credit is also referred to as valuation percentage. If a particular sovereign bond has a haircut of 5% and a collateral call of $100,000 is made, only 95% of the collateral's value is credited for collateral purposes. That is, in order to satisfy a $100,000 collateral call, $105,263 (= $100,000 / 0.95) of the sovereign bond must be posted. (LO 34.g)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Gregory, Chapter 8.

READING 35

CENTRAL CLEARING

Study Session 6

EXAM FOCUS

This topic discusses the structure of a central counterparty (CCP) as well as the advantages and disadvantages of central clearing though a CCP. For the exam, understand the fundamental issues related to multilateral offset, over-the-counter (OTC) derivatives clearing, wrong-way risk (WWR), loss mutualization, and margin requirements. Multilateral offset offers the benefits of reduced counterparty and systemic risks. However, there are challenges related to standardization, complexity, liquidity, and WWR that make it difficult to centrally clear OTC derivatives. Also, understand the structure of the CCP loss waterfall as a way to manage the default of a CCP member. Be prepared to explain how setting adequate initial and variation margins plays a key role in ensuring that loss mutualization is efficiently obtained through the CCP loss waterfall.

MODULE 35.1: CENTRAL COUNTERPARTIES

LO 35.a: Define a central counterparty (CCP) and describe the mechanics of central clearing.

A **central counterparty (CCP)** has become a solution for systemic risk mitigation. CCPs provide clearing services for many different types of financial transactions between member firms. They are involved in "complete clearing," which means they essentially stand in the middle of previously bilateral over-the-counter (OTC) transactions and operate as the buyer for every seller and vice versa. Through this process, the original counterparty is no longer a direct risk as the CCP conceptually becomes the new counterparty. Figure 35.1 shows a traditional bilateral counterparty structure where default risk is directly borne by the individual counterparties.

Figure 35.1: Bilateral Structure

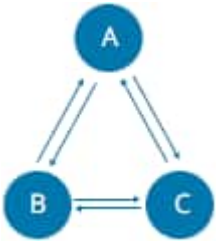
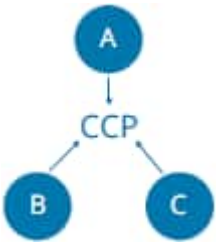


Figure 35.2 shows how a CCP structure changes the traditional risk landscape with the CCP acting as the middleman in all risk transactions. Through this new structure, a CCP can reduce market interconnectedness because Party A is no longer directly exposed to the full losses of Party B or Party C, for example. There is greater transparency because the CCP is aware of all member positions.

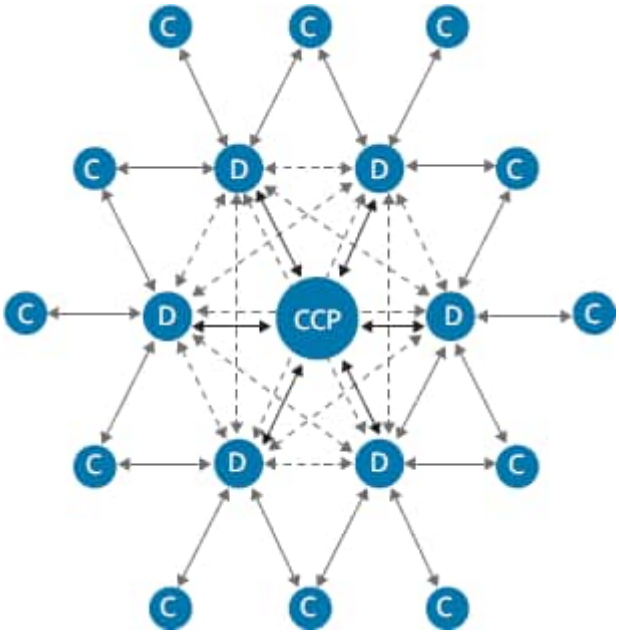
However, there is some potential added complexity as some counterparties do not access a CCP directly but rather through a backchannel using one of the member firms. For example, there might be a Party D who is a nonmember firm within a given CCP, but Party D might still clear financial transactions using Party C, who is a member firm, as a conduit. This may add an additional layer of complexity regarding margin transfer and default scenarios, for example.

Figure 35.2: CCP Structure



To get a fuller picture, Figure 35.3 shows a centrally cleared market with bilateral transactions (dotted lines), directly-cleared transactions (black lines), and nonclearing members (C) who must clear with the assistance of clearing members (D) (gray lines). Note that there will always be some OTC derivatives that cannot be centrally cleared and, therefore, can only exist as bilateral transactions.

Figure 35.3: Centrally Cleared Market



Source: Jon Gregory, *The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital*(West Sussex, UK: John Wiley & Sons, 2020). Chapter 8.

To elaborate on Figure 35.3, the existence other CCPs and their interconnectedness must be considered because members of one CCP may also be members of another CCP. Although there are clear advantages of central clearing, there is a significant form of *concentration risk* in that a major error or failure at the CCP level could prove to be disastrous for all members involved.

Mechanics of Central Clearing

CCPs operate primarily by charging fees on all trades and to a lesser extent by earning income on the assets in their possession. The total number of CCPs in a global market must be small enough to be efficient but large enough to mitigate concerns of severe systemic risk or political issues. There are some advantages of allowing fewer CCPs to have monopolistic control over clearing. Competition between CCPs could lead to concerns regarding the credit quality of the CCPs, which supports a monopolistic structure. However, that also increases the risk of severe systemic risk which could result from the collapse of a CCP when there are too few to absorb the impact. Multilateral netting benefits such as reducing risk exposures and gaining economies of scale support the argument for a small number of CCPs.

However, jurisdictional fragmentation, the variety of products, the need for competition, and the risk of severe systemic risk are all factors suggesting that the number of CCPs should be greater. In the context of jurisdictional fragmentation, it may be necessary for clearing to occur for trades in a certain local currency (e.g., USD, EUR) and some regulators may insist that financial institutions clear their transactions only through a national or regional CCP. In terms of products, a single CCP often focuses on specific products and, therefore, will not be able to clear all OTC derivatives. The existence of a wide range of OTC derivatives would require multiple CCPs.

CCP ownership and logistics can be roughly divided into two categories: vertical and horizontal. With a vertical scheme, an exchange owns the CCP and the CCP operates as a unit within the exchange by only clearing products associated with that exchange. With a horizontal scheme, the clearing members usually own the CCP collectively, and without being tied to a specific exchange, the CCP is able to transact in a much wider range of markets and asset classes. In practice, the horizontal scheme works best for bilateral OTC derivatives and allows for greater competition than the vertical scheme, which is viewed favorably by regulators. In short, greater competition is likely to result in lower costs and a higher standard of clearing services.

Many OTC derivatives are currently cleared through CCPs, and the volume will continue to grow in the future. New products are more problematic as it takes time for them to develop the characteristics needed for clearing. When examining derivative products clearing in a CCP setting, the following characteristics must be considered: (1) standardization, (2) complexity, (3) liquidity, (4) wrong-way risk, and (5) market volume.

- *Standardization.* Because the clearing process means that the CCP is legally liable for all cash flows associated with the product, OTC derivative products such as credit default swaps (CDSs) must be standardized before they can be cleared through a CCP. Standardization also facilitates the netting process for the same or similar contracts.
- *Complexity.* Exotic or more complex derivatives are problematic for CCPs because their unique features make them difficult to value (even if they are standardized). Therefore, only nonexotic and less complex derivatives are clearable by CCPs because those derivatives can be easily, reliably, and quickly valued. The valuation is important for initial and variation margin computations and to avoid the risk associated with under-margining or the opportunity costs associated with over-margining.
- *Liquidity.* CCPs can only clear products that are liquid. In that regard, CCPs face pricing issues for illiquid products, which have less information and historical data that can be used for calculating initial and variation margins. Furthermore, the illiquidity and complexity of products makes it difficult to calibrate valuation models, which increases the risk for CCPs in the event of default. Illiquid products will also increase the time horizon needed for replacing defaulted trade positions.
- *Wrong-way risk (WWR).* Products with WWR are not optimal for CCPs. WWR introduces complexity and creates additional problems for CCPs in the event of default (i.e., WWR is the positive correlation between default risk and credit exposure to a counterparty). The presence of WWR can lead to an increase in risk exposures resulting from the default of a CCP member.
- *Market volume.* Sufficient market volume for a specific product is necessary in order for a CCP to clear that product given the upfront costs involved in developing the expertise to do so.

Novation

LO 35.b: Explain the concept of novation under central clearing.

In the event of a default, a CCP must replace nonperforming contracts through a process formally known as novation. **Novation** involves closing out the nonperforming side of a bilateral contract with a new counterparty (i.e., the CCP) that is capable of meeting the contractual obligations. Essentially, the CCP takes on the counterparty risk upon novation as the original parties no longer have contractual obligations to each other.

The transaction is guaranteed once buyers and sellers are matched. In that regard, the CCPs remain market neutral by netting all buy-side transactions with offsetting sell-side transactions (i.e., with the matched book). However, market risk will be introduced upon default by either party because the matched book will no longer be in place. The CCP may attempt to sell off the defaulting party's positions to restore the matched book. Additionally, the CCP may require default fund contributions by all member firms so that losses are mutualized and spread over a larger number of market participants rather than concentrating them with a single party. Further details on default funds will be discussed shortly.

Netting, Multilateral Offset, and Compression

LO 35.c: Define netting, multilateral offset, and compression and provide examples of each.

The bilateral derivatives market, by its nature, likely has a significant number of redundant transactions that raise the level of counterparty risk. **Netting** and **multilateral offset** are used to reduce the number of transactions. These two concepts are closely related as demonstrated in Figure 35.4. The use of CCPs is desirable because it can achieve multilateral offsets for cash flows and margins, for example.

Figure 35.4: Multilateral Netting

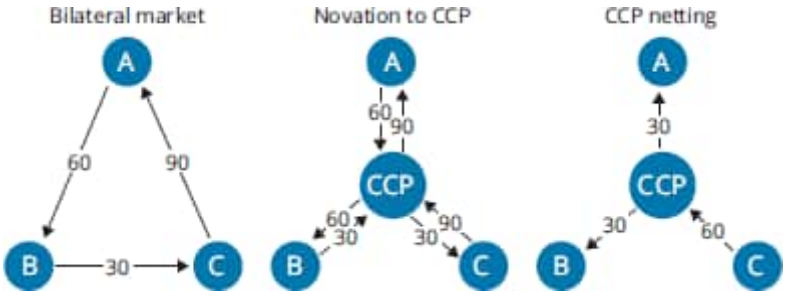


Figure 35.4 shows the liabilities between parties based on the directions of the arrows. With the bilateral market, the total liabilities are 180 (= 30 + 60 + 90). Here, Party A owes Party B an amount of 60. At the same time, Party C owes Party A an amount of 90. If Party C defaults and does not pay Party A the amount of 90, then it is quite possible

that Party A will also default because it does not have sufficient funds to pay Party B the amount owing of 60.

As an alternative, when considering novation in the second component of Figure 35.4, the CCP steps into the middle of all the parties, which allows for the netting of the transactions, which then leads to the third component of Figure 35.4. For example, the two transactions between Party A and the CCP (60 and 90) would net out to 30. Overall, risk is reduced as shown by the lower liability of Party C (previously 90 but reduced to 60 with netting) and Party A no longer owes 60 to Party B but instead is owed 30 by the CCP.

Compression involves the cancellation of real transactions on an absolute or gross basis, without relying on the offsetting benefits of multilateral offsets. In general terms, with compression, multiple offsetting contracts are canceled and substituted with fewer contracts to lower the gross exposures of both parties but maintaining the net exposures. For example, assuming there are 10 offsetting transactions between Parties A and B with a gross exposure of $1 million and a net exposure of $250,000 to Party A. Compression may allow the reduction of the number of transactions to, say five, and reduce the gross exposure to, say $350,000, while maintaining the net exposure of $250,000.

In comparing the compression example (e.g., compressing transactions and/or cash flows) to multilateral offset, the latter is able to compress risk without having to cancel any transactions. Compression can be used in conjunction with central clearing. From an efficiency standpoint, it makes sense to have fewer transactions and to have lower notional amounts cleared by a CCP. Specifically, there could be reductions in initial margin requirements, regulatory capital, and administrative work relating to margin calculations and reporting.

In practice, although the amount of notional cleared continues to increase for interest rates swaps, for example, the amount of notional outstanding remains virtually the same. Compression techniques are becoming more sophisticated including the ability to compress positions that have the same cash flow dates but different fixed rates.

MODULE QUIZ 35.1

1. There are numerous challenges when clearing over-the-counter (OTC) derivative products through a central counterparty (CCP). Which of the following lists best summarizes the key challenges for central clearing of OTC derivative products?
   A. Illiquid products, jurisdictional fragmentation, presence of wrong-way risk, and legal concerns.
   B. Lack of standardization, increased counterparty risk, increased dependency risk, and less transparency.
   C. Jurisdictional fragmentation, increased counterparty risk, less transparency, and standardization.

D. Product complexity, illiquid products, presence of wrong-way risk, and lack of standardization.

MODULE 35.2: CCP RISK MANAGEMENT

LO 35.d: Describe the application and estimation of margin and default funds under central clearing.

With central clearing, initial and variation margins play important roles to mitigate the risk of member default or bankruptcy. **Initial margin** is the beginning deposit required from all members to cover future potential default losses in a worst-case scenario. **Variation margin** is the additional margin required to account for daily price changes in asset positions; intraday margin calls are used during periods with large market movements. Similar to variation margin, initial margin depends primarily on market risk rather than the credit quality of the clearing member.

The time period in which a CCP could be exposed to a position as well as the required confidence level (i.e., the percentage of default scenarios the margin will cover) for the CCP are important factors in determining the initial margin level. The idea is to have a sufficient provision for losses for a given member to a high enough level of confidence (usually 99% or more) so that losses do not have to be covered by other members.

In a perfect world, each member would contribute enough money to the CCP to pay for 100% of their potential losses but that amount could be prohibitively high. Instead of such a high standard, loss mutualization occurs whereby members are required to contribute money into the CCP's **default fund** at a level that would cover potential losses with a high degree of confidence.

Within the CCP structure, a member's liability for default losses may occur indirectly. For example, the loss allocation process may result in a member being liable for a share of the default losses even though that member had no direct dealings with the defaulting member or no net position with the CCP.

LO 35.e: Discuss the risks faced by a CCP and the ways it manages its exposures.

Membership Requirements

CCPs face general risks from their clearing members; therefore, CCPs impose membership requirements to manage those risks. The membership requirements focus on creditworthiness (e.g., low likelihood of default), liquidity (e.g., ability to cover margin calls quickly), and likelihood of compliance with CCP rules. Upon acceptance as clearing members, CCPs manage the risk of clearing members by imposing requirements pertaining to minimum capital base, default fund contributions, and default management participation.

Margin

As discussed earlier, margin is used as the main form of risk mitigation by a CCP in the event of member default. Typically, only cash is accepted as variation margin, and

netting in a single currency is possible but not in different currencies. In contrast, cash and highly liquid (government) securities are accepted as initial margin. Initial margin is a complex computation that uses various scenarios of price changes during a specified trade horizon.

CCPs hold a significant amount of margin on which they usually pay interest on excess cash deposited as initial margin. As a result, it necessary for the CCP to conservatively invest the margin funds in low-risk investments to generate sufficient income to pay interest.

Member Default

Member default is the CCP's overwhelmingly main risk. Default results in an unmatched book because the defaulting member (who is assumed to have incurred a loss) is not making the required variation margin payment to the members who have a gain. Therefore, the CCP must make the variation margin payment instead. In a default, the CCP reduces its risk through macro-hedging and auctions.

Through the default management group, **macro-hedging** aims to significantly reduce portfolio exposure to major market risks (e.g., interest rate volatility).

With a member default, the CCP's goal is to quickly liquidate the defaulted member's portfolio to minimize realized losses. This is done by **auctioning** the portfolio (by subportfolios) to members. Clearing members have an incentive to participate in this auction to work out the smallest possible loss for the CCP's collective member group and avoid going down the loss waterfall (see next section). In this way, the CCP structure may yield a higher auction price for defaulted assets than would be achieved in the open market. Also, because the macro-hedges were already in place, the defaulted subportfolios will have little or no market risk, which should increase their attractiveness and help ensure sufficiently high bid prices offered by surviving members.

From an efficiency standpoint, it makes the most sense to port the defaulted member's trades to a surviving member who must accept everything on an "as is" basis. If porting does not work, then the trades and the defaulted member's portfolio are taken to the default management process. As a first step, the initial margins are taken to cover the losses.

Margin Period of Risk

The **margin period of risk (MPoR)** is also known as the liquidation period. CCPs can lower the MPoR through very frequent (e.g., at least daily) cash collateral calls; cash does not result in any settlement delays. Additionally, CCPs can close out positions quite rapidly because it is quite easy for them to declare a member in default and then work through the steps of an efficient default management process without challenge.

The MPoR can be subdivided into three distinct periods:

1. *Predefault.* This begins from the time of the member's most recent margin posting until the time the CCP declares the member in default.

2. *Macro-hedging.* The most important market risks are reduced substantially and quickly using liquid hedges.
3. *Auctions.* The defaulting member's portfolio is sold off and risk will decrease to zero with the wrap-up of each auction and closing of positions.

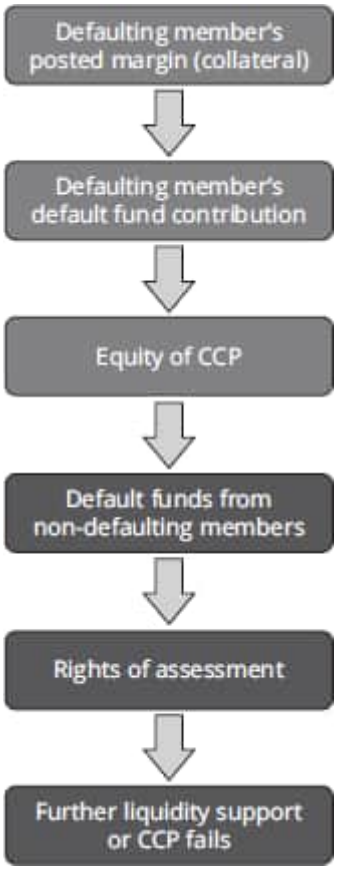
CCP Loss Waterfall

LO 35.f: Provide examples of a loss waterfall.

LO 35.g: Explain the different methods of managing the default of one or more members of a CCP.

Figure 35.5 illustrates how CCP member defaults are absorbed in a **loss waterfall**.

Figure 35.5: CCP Loss Waterfall


Defaulting member's posted margin (collateral)
Defaulting member's default fund contribution
Equity of CCP
Default funds from non-defaulting members
Rights of assessment
Further liquidity support or CCP fails

In the event of a CCP member default, the macro-hedging and auction costs are initially covered by the member's initial margin and default fund contributions (see Stage 1 and 2 of Figure 35.5). In other words, the first stage in the loss waterfall is for the defaulting member to sacrifice the collateral that they posted when their transaction was initiated and when daily marking-to-market occurred.

After the collateral and the default fund contributions from a defaulting member have been exhausted to remedy a realized loss, Stage 3 of Figure 35.5 indicates that the CCP will dip into its own equity capital to a point where the CCP would still be able to

function normally. This is an equity contribution from the CCP (i.e., "skin in the game"); such a potential cash outflow means that the CCP may want to make careful assessments to set the initial margins and default fund contributions sufficiently high for members so that the CCP is able to avoid equity contributions.

If a loss still remains after Stage 3, then the **loss mutualization** process takes over whereby the "surviving" members pay. The first layer of this process (Stage 4 of Figure 35.5) is to use contributions to the CCP's default fund from nondefaulting members. Loss allocation could be done on a pro rata basis or in a way that allocates fewer losses to those who bid successfully in the auction.

Rights of Assessment

In rare and extreme loss situations that liquidate a sizable portion of the CCP's default fund (e.g., 25%), member firms may need to make additional contributions to the default fund to restore it and prevent the CCP from total liquidation and collapse. These additional contributions are known as **rights of assessment** (see Stage 5 of Figure 35.5) and are usually limited to a specific amount per period. Limits are desirable to ensure that members are not faced with onerous cash outflows especially during an economic downturn when they are least able to make additional contributions.

Variation Margin Gains Haircutting

Variation margin gains haircutting (VMGH) is an alternative solution which assumes that losses incurred by defaulting members would have corresponding gains accrued by other members. VMGH involves the CCP "discounting" the incremental margin paid to the members who have gains so that they only receive a partial amount of what they otherwise would have received. At the same time, amounts owed to the CCP must be satisfied in full. Assuming a CCP is able to transact at midmarket prices for the defaulted portfolio, the VMGH will be successful. However, if the CCP is forced to transact at a large premium above midmarket prices, then the VMGH may fail.

Tear-Up

If the auction does not work, the CCP may cancel (or complete a **tear-up**) of unmatched contracts with clearing members. The tear-up simply strives to restore the CCP to a matched book by canceling trades that were opposite to those of the defaulting member. A key distinction between tear-up and VMGH is that the CCP will not need to pay risk premiums that could otherwise occur with an auction. Partial or complete tear-ups are possible; the latter of which is favorable for the CCP, but the clearing members will incur losses and residual market risk.

Forced Allocation

Forced allocation requires members to take specific positions for amounts specified by the CCP. The end effect is close to that of tear-up, but unlike a tear-up, the existing trade is not canceled. Instead, the member may be forced to transact in a reverse trade, for example. Tear-ups demand that the member already has the relevant trades in place whereas forced allocation does not require it. Additionally, tear-ups could allow the

clearing member to pass financial impacts to their clients but the same cannot be done with forced allocation.

Further Liquidity Support

In short, loss allocation methods such as tear-up and forced allocation are very onerous (e.g., liability could be infinite). In that regard, if the needs of a CCP are excessive, then it could be detrimental to the survival of the member firms. In this case, the CCP will either fail or require external liquidity support from a well-capitalized entity like a central bank (see Stage 6 of Figure 35.5). Some CCPs may have other (costly) sources of liquidity not listed in Figure 35.5 such as bank lines of credit or guarantees from insurance companies. Ultimately, it is important to remember that full movement down the loss waterfall is an extremely low probability event.

It is also noteworthy that CCPs are not permitted to touch the initial margin of nondefaulting members despite the potential to use initial margin haircutting as a form of loss allocation. However, loss allocation methods such as tear-up and forced allocation may impose infinite liability on a member so the "safety" of the initial margin of nondefaulting members may ultimately be irrelevant.

MODULE QUIZ 35.2

1. Which of the following statements regarding risk management by central counterparties (CCPs) is most accurate?
   A. Netting in different currencies is possible.
   B. Only cash is accepted as variation margin.
   C. An important source of returns for CCPs is the interest earned on held assets.
   D. During the margin period of risk (MPoR), most of the risk is reduced with auctions where the defaulting member's portfolio is sold off.

2. Given the following three events, what is the proper order of the CCP loss waterfall?
   I. Nondefaulting member's default fund contributions are exhausted.
   II. Defaulting member's collateral and default fund contributions are exhausted.
   III. CCP taps an amount of its equity that enables them to function normally.
   A. I, II, III.
   B. II, I, III.
   C. II, III, I.
   D. III, II, I.

MODULE 35.3: CENTRAL CLEARING MARKET IMPACT

Bilateral vs. Central Clearing

LO 35.h: Compare bilateral and central clearing.

The notion of a centrally cleared OTC derivatives market is best evaluated by contrasting it against a bilateral market.

Key characteristics of **bilaterally cleared markets** include the following:

- *Counterparty*. In a bilateral market, the original counterparty remains in effect as long as the contract remains in effect.
- *Available products*. There are no limitations to products that can be used in bilateral markets. As long as the two parties agree to the terms of a contract, then it is able to be created.
- *Eligible participants*. Participation in bilateral markets is open to any and all market actors. The only exclusion would be if someone has such weak credit that no counterparty would be willing to take the opposite side of their trade.
- *Contract netting*. Any netting of contracts to offset risks will need to be manually and intentionally arranged by players in bilateral markets. Typically, trades are not offset as market participants are placing bets on specific events, which means they do not wish to be market neutral.
- *Margining*. Two bilateral counterparties are able to negotiate customized collateral arrangements. New regulatory rules are trying to standardize this factor, but for now, there is a great deal of flexibility.
- *Close-out of default positions*. Close-out of a default position can be messy in a bilateral market. This process is entirely between two bilateral counterparties and may quickly result in a default scenario for the entire counterparty and not just the isolated transaction.
- *Loss absorbency cost*. Loss absorption is mostly through capital although increasingly through initial margins.

Key characteristics of **centrally cleared markets** include the following:

- *Counterparty.* In a centrally cleared market, the original counterparty is effectively replaced when the CCP steps into the middle of the transaction. Through the CCP structure, the CCP becomes the new counterparty and the other CCP members become secondary counterparties.
- *Available products*. Financial products traded in centrally cleared markets must be standardized, plain-vanilla (nonexotic), and liquid. This helps to limit loss potential from specialized contracts, but it also limits the flexibility of types of contracts that can be used within the CCP structure.
- *Eligible participants*. Centrally cleared markets are only open to clearing members, which are typically large financial institutions. Other entities may clear transactions by using a clearing member as a conduit only if they are willing and able to post the necessary collateral and a clearing member is willing to sponsor them.
- *Contract netting*. CCPs naturally try to remain market neutral by netting financial transactions. This process helps to further spread out risks.
- *Margining*. A centrally cleared market has transparent collateral requirements and margin rules with daily or intra daily posting. These rules are static and nonnegotiable for member firms.
- *Close-out of default positions*. A coordinated default process is one of the hallmarks of a centrally cleared market. The loss waterfall is the heart of this process, and it has the potential to not let a default on a single asset result in the complete default of an

individual member firm. This coordinated close-out structure helps to minimize internal costs due to operational efficiencies and also minimize legal risk because the member firms are already engaged in a rules-based transactional relationship.

- *Loss absorbency cost.* Loss absorption is mostly through initial margin and through funds provided by clearing members to the default fund.

Initial Margin and Default Fund Requirements

LO 35.i: Compare initial margin and default fund requirements for clearing members in relation to loss coverage, cost of clearing, and moral hazard.

In simplified terms, initial margin is designed to provide very high likelihood (e.g., 99%) of sufficient coverage of any losses suffered by a CCP due to a member default. Despite such strong assurances, there is always the possibility that losses will occur when the initial margin is insufficient.

The default fund covers losses not covered by the initial margin. Given the nature of the loss distributions, if the margin is insufficient then there are likely extreme losses. The amount of coverage required would also be extreme and, therefore, the default fund uses a risk pooling system that shares a large loss from one CCP member with all other members. Because the default fund is mutualized, it means that default fund contributions by each member are relatively small, and the default fund will have much more loss absorbency compared to initial margin.

The split between initial margin and default fund is subjective and there are multiple approaches. Larger initial margins and smaller default funds have a higher clearing cost but are more consistent with the defaulter paying for the losses it causes. This encourages better behavior, so, as a result, moral hazard is lower. This, in turn, encourages clearing members to provide portability (i.e., allow clients to move their portfolio to another clearing member).

In contrast, smaller initial margins and larger default funds have a lower clearing cost but elevate moral hazard. This is because there is greater likelihood of losses being covered by default funds and less consistency with the defaulter paying for the losses it causes. This discourages clearing members from providing portability as there may not be enough initial margin, thereby requiring the clearing members to pay additional amounts into default funds.

The default fund serves to lower clearing costs through a process of loss mutualization to absorb potentially large losses exceeding those covered by the initial margins. An accurate computation of the optimal default fund size is problematic due to extreme complexities, therefore, CCPs must estimate the default fund size using stress tests. The size would likely be expressed in terms of how many defaults the CCP can absorb (e.g., one or two). From there, the loss allocation process can be done in a straightforward manner (e.g., pro rata based on position size or initial margin).

Advantages and Disadvantages of Central Clearing

LO 35.j: Describe the advantages and disadvantages of central clearing.

While the central clearing process does not fully eliminate counterparty risk, it does greatly reduce it from a traditional bilateral model. The advantages and disadvantages of the CCP structure are summarized here.

The advantages of a CCP include the following:

- *Transparency.* Unlike bilateral markets, a CCP can see aggregate risk concentrations because they are aware of many of the transactions of their member firms. This enables the CCP to take mitigating actions to potentially offset risks that it notices early on.
- *Multilateral offset.* The transparency of the CCP structure enables risk to be offset. The offsetting process eliminates the need for members to monitor the creditworthiness of other members. This process also lowers margin costs for member firms.
- *Loss mutualization*. In the event that a CCP member defaults, the CCP will manage the default using the loss waterfall where realized losses may be shared by all members of the CCP. This reduces the market impact of a default scenario and reduces systemic risk.
- *Legal and operational efficiency.* Both netting and the collateral policies of a CCP increase operational efficiency and lower costs. Legal costs are also minimized due to the rules-based structure of a CCP.
- *Liquidity.* Greater ability for members to trade and use multilateral offset leads to enhanced market transparency and, therefore, improved market liquidity.
- *Default management.* The CCP also manages default scenarios with an orderly auction of the defaulted member's position. This brings stability to the market and secures the best price possible for the market.

The disadvantages of a CCP include the following:

- *Moral hazard.* This well-known insurance industry concept can be applied to the CCP structure because there is little incentive for member firms to vet the creditworthiness of other member firms. The netting, collateralization, and loss mutualization process contribute to this view.
- *Adverse selection.* Most CCP member firms specialize in derivative contracts. As such, they may have superior knowledge on pricing and risk compared to the CCP. This creates an environment where the member firms may choose to trade with CCPs that offer the best prices due to incomplete information.
- *Bifurcations.* The fact that CCPs are required to only clear standard contracts has created a bifurcated market where some trades are processed through clearing firms, and some are not. This reduces the benefit of multilateral offset.
- *Procyclicality.* Procyclicality refers to a positive correlation between an event and the state of the economy. As the market and economy become more volatile, CCPs

generally increase collateral requirements, which can further exacerbate a potential default scenario.

MODULE QUIZ 35.3

1. Which of the following statements is not an improvement that centrally cleared markets offer relative to bilateral markets? Centrally cleared markets:
   A. remain market neutral by netting trades.
   B. formalize the default workout process by using a loss waterfall structure.
   C. offer more flexibility in contract selection because of their collateral collecting process.
   D. improve the counterparty risk picture by replacing the original counterparty with a series of counterparties.

2. Following the financial crisis of 2007–2009, the roles of central counterparties (CCPs) were increased to reduce systemic risk through a centralized clearing process. Which of the following actions is not an advantage of the CCP in the centralized clearing process?
   A. Increase transparency.
   B. Manage loss mutualization.
   C. Eliminate counterparty risk.
   D. Improve operational efficiency.

KEY CONCEPTS

LO 35.a

A central counterparty (CCP) has become a solution for systemic risk mitigation. CCPs essentially stand in the middle of previously bilateral over-the-counter (OTC) transactions and operate as the buyer for every seller and vice versa. When examining derivative products clearing in a CCP setting, the following characteristics must be considered: standardization, complexity, liquidity, wrong-way risk, and market volume.

Multilateral netting benefits such as reducing risk exposures and gaining economies of scale suggest that there should be a small number of CCPs. However, jurisdictional fragmentation, the variety of products, the need for competition, and the risk of severe systemic risk are all factors suggesting that there should be a greater number of CCPs.

LO 35.b

Novation involves closing out the nonperforming side of a bilateral contract with a new counterparty (i.e., the CCP) that is capable of meeting the contractual obligations. Essentially, the CCP takes on the counterparty risk upon novation as the original parties no longer have contractual obligations to each other.

LO 35.c

The bilateral derivatives market, by its nature, likely has a significant number of redundant transactions that raise the level of counterparty risk. Netting and multilateral offset are used to reduce the number of transactions. The use of CCPs is desirable because it can achieve multilateral offsets for cash flows and margins, for example.

Compressing portfolios involves the cancellation of real transactions on an absolute or gross basis, without relying on the offsetting benefits of multilateral offsets. In general terms, with compression, multiple offsetting contracts are canceled and substituted with fewer contracts to lower the gross exposures of both parties while maintaining the net exposures.

LO 35.d

Initial margin is the beginning deposit required from all members to cover future potential default losses in a worst-case scenario. Variation margin is the additional margin required to account for daily price changes in asset positions; intraday margin calls are used during periods with large market movements. Similar to variation margin, initial margin depends primarily on market risk rather than the credit quality of the clearing member.

LO 35.e

CCPs impose membership requirements, which focus on creditworthiness, liquidity, and likelihood of compliance with CCP rules.

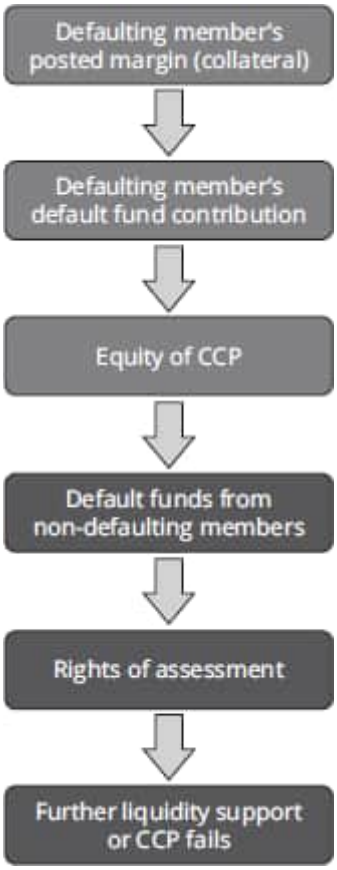
Margin is used as the main form of risk mitigation by a CCP in the event of member default. Typically, only cash is accepted as variation margin, and cash and highly liquid (government) securities are accepted as initial margin.

Member default is the CCP's main risk. In a default, the CCP reduces its risk through macro-hedging and auctions.

The margin period of risk (MPoR) is the liquidation period, and it can be subdivided into three distinct periods: predefault, macro-hedging, and auctions.

LO 35.f

The loss waterfall summarizes how CCP member defaults are absorbed. A typical loss waterfall is illustrated as follows:


Defaulting member's posted margin (collateral)
Defaulting member's default fund contribution
Equity of CCP
Default funds from non-defaulting members
Rights of assessment
Further liquidity support or CCP fails

LO 35.g

In rare and extreme loss situations that liquidate a sizable portion of the CCP's default fund, member firms may need to make additional contributions (rights of assessment) to the default fund to restore it and prevent the CCP from total liquidation and collapse.

Variation margin gains haircutting (VMGH) involves the CCP "discounting" the incremental margin paid to the members who have gains so that they only receive a partial amount of what they otherwise would have received. At the same time, amounts owed to the CCP must be satisfied in full.

Assuming the auction does not work, the CCP may cancel (or tear-up) unmatched contracts with clearing members. The tear-up simply strives to restore the CCP to a matched book by canceling trades that were opposite to those of the defaulting member.

Forced allocation requires members to take specific positions for amounts specified by the CCP. The end effect is close to that of tear-up, but unlike a tear-up, the existing trade is not canceled. Instead, the member may be forced to transact in a reverse trade, for example.

If the needs of a CCP are excessive, then it could be detrimental to the survival of the member firms. In this case, the CCP will either require external liquidity support from

a well-capitalized entity like a central bank or face failure.

LO 35.h

Key characteristics of bilaterally cleared markets are as follows:

- The original counterparty remains in effect as long as the contract remains in effect.
- There are no limitations to products that can be used in bilateral markets.
- Participation in bilateral markets is generally open to any and all market actors.
- Any netting of contracts to offset risks will need to be manually and intentionally arranged by players in bilateral markets.
- Two bilateral counterparties are able to negotiate customized collateral arrangements.
- Close-out of a default position is entirely between two bilateral counterparties and may quickly result in a default scenario for the entire counterparty and not just the isolated transaction.
- Loss absorbency cost is mostly through capital.

Key characteristics of centrally cleared markets are as follows:

- The original counterparty is effectively replaced when the CCP steps into the middle of the transaction.
- Financial products traded in centrally cleared markets must be standardized, plain-vanilla (nonexotic), and liquid.
- Centrally cleared markets are generally only open to clearing members, which are typically large financial institutions.
- CCPs naturally try to remain market neutral by netting financial transactions.
- Transparent collateral requirements and margin rules with daily or intradaily posting. These rules are static and nonnegotiable for member firms.
- A coordinated default process is one of the hallmarks of a centrally cleared market. The loss waterfall is the heart of this process, and it has the potential to not let a default on a single asset result in the complete default of an individual member firm.
- Loss absorbency cost is mostly through initial margin and through funds provided by clearing members to the default fund.

LO 35.i

The strengths and weaknesses of using different amounts of initial margin and default fund contributions are summarized as follows:

	Higher Initial Margin/ Lower Default Fund	Lower Initial Margin/ Higher Default Fund
Cost	Higher	Lower
Client clearing	Clients pay for their own risk using initial margin.	Clients do not directly pay for their own risk.
	Portability is encouraged.	Portability is a challenge.
Moral hazard	Lower	Higher

LO 35.j

The advantages of a CCP include transparency, multilateral offset, loss mutualization, legal and operational efficiency, liquidity, and default management.

The disadvantages of a CCP include moral hazard, adverse selection, bifurcations, and procyclicality.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 35.1

1. **D** Lack of standardized products, complexity, illiquid products, and the presence of wrong-way risk are characteristics of OTC derivative products that make CCP clearing challenging. OTC derivative products need to be standardized before they can be cleared through a CCP. More complex and illiquid derivative products are problematic for CCPs because their unique features make them difficult to value. Products with wrong-way risk are also more complex and create additional concerns for CCPs in the event of default. (LO 35.a)

Module Quiz 35.2

1. **B** Usually, only cash is accepted as variation margin. Netting in a single currency is possible but not in different currencies. CCPs operate primarily by charging fees on all trades and to a lesser extent by earning income on the assets in their possession. The most important risks are reduced substantially and quickly using liquid hedges via macro-hedging. (LO 35.e)

2. **C** The first layer in the loss waterfall is for the defaulting member's collateral and default fund contributions to be exhausted. The next layer is for the CCP to tap into its own equity to the point where it could still function normally. Nondefaulting members will then have their default funds exhausted before moving to the rights of assessment. (LO 35.f)

Module Quiz 35.3

1. **C** Bilateral markets permit any type of customized financial contract and customized collateral that is freely negotiated between the two bilateral parties. In a centrally cleared market, flexibility is reduced because contracts must be standardized, and collateral rules are fixed and nonnegotiable. (LO 35.h)

2. **C** CCPs reduce counterparty risk, but they do not eliminate this risk. Improved legal and operational efficiencies, increased transparency, and loss mutualization are major advantages of the CCP central clearing process. (LO 35.j)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Gregory, Chapter 11.

READING 36

FUTURE VALUE AND EXPOSURE

Study Session 6

EXAM FOCUS

In this reading, we describe credit exposures for various security positions. For the exam, understand credit exposure metrics and their application. Be prepared to identify potential future exposure (PFE) for the various asset classes discussed. Understand how credit exposure and VaR methods compare, and be able to explain credit exposure factors. Know how payment frequencies and exercise dates impact exposure profiles. Also, be familiar with netting tables and be able to calculate the netting factor. Understand the impact of collateral attributes on credit exposure reduction and know the steps in computing the margin period of risk (MPoR). Finally, be able to explain the difference between risk-neutral and real-world parameters in arbitrage models and risk management applications.

MODULE 36.1: CREDIT EXPOSURE

Credit Exposure Metrics

LO 36.a: Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective expected positive exposure, and maximum exposure.

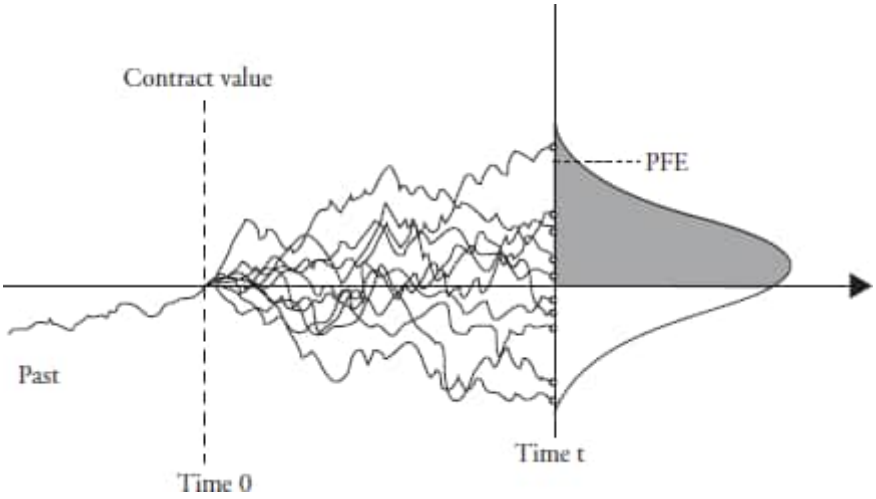
Expected mark to market (MtM) is the expected value of a transaction at a given point in the future. Long measurement periods as well as the specifics of cash flows may cause large differences between current MtM and expected MtM.

Expected exposure (EE) is the amount that is expected to be lost if there is positive MtM and the counterparty defaults. Expected exposure is larger than expected MtM because the latter considers both positive and negative MtM values.

Potential future exposure (PFE) is an estimate of MtM value at a specific point in the future. It is usually based on a high confidence level, taking into account the worst-case scenario. The current MtM may follow a number of different possible paths into the

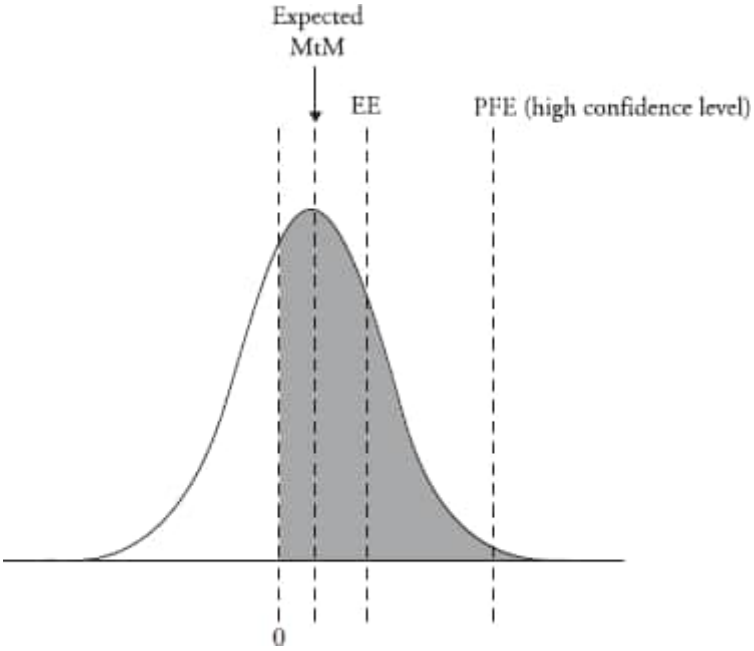
future, so a probability distribution of PFE can be derived, similar to the one shown in Figure 36.1. Positive MtM (the shaded area in Figure 36.1) is the part of the exposure that is at risk. Any points in this shaded area can represent PFE.

Figure 36.1: Potential Future Exposure



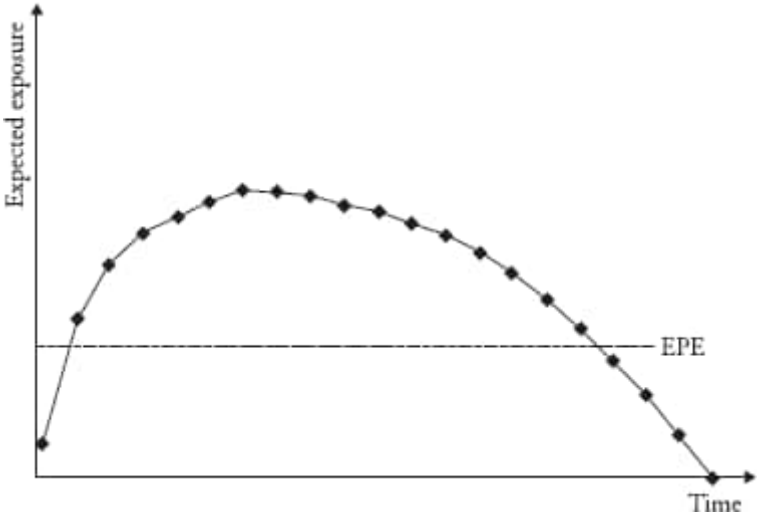
In other words, PFE is the worst exposure that could occur at a given time in the future at a given confidence level. Potential future exposure represents a "gain" amount because it is the amount at risk if the counterparty defaults. **Maximum PFE** is the highest PFE value over a stated time frame.

Figure 36.2: Credit Exposures



Expected positive exposure (EPE) is the average EE through time. Expected positive exposure is a useful single amount to quantify exposure.

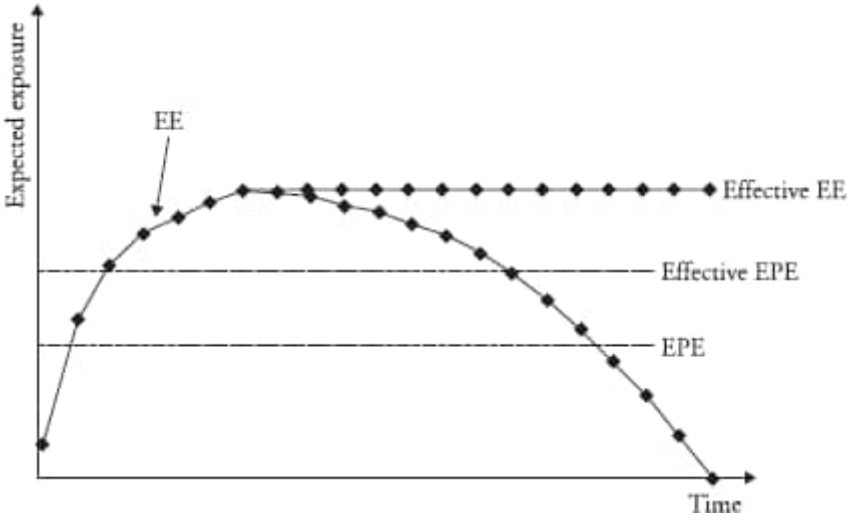
Figure 36.3: Expected Positive Exposure



Negative exposure, which is the exposure from the counterparty's point of view, is represented by negative future values. The expected negative exposure (ENE) is the exact opposite of EPE.

The **effective EE** and **effective EPE** measures are meant to properly capture rollover risk for short-term transactions (under one year). Effective EE is equal to nondecreasing EE. Effective EPE is the average of the effective EE.

Figure 36.4: Effective EE and Effective EPE



Comparing Credit Exposure to VaR Methods

LO 36.b: Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure.

Value at risk (VaR) is a measure used to estimate the risk of loss on a portfolio of financial/investment assets (e.g., stocks, bonds, derivatives, etc.). For example, if an asset portfolio has a one-day 10% VaR of $100,000, there is a 10% probability that the market value of the portfolio will fall by more than $100,000 over a period of one day.

The characterization of credit exposure is similar to the characterization of VaR, although additional considerations are relevant to credit exposure, described as follows:

- *Application*: Credit exposure is defined for both pricing and risk management, whereas VaR is just for risk management. As a result, quantifying credit exposure is more difficult and may result in different calculations for both pricing and risk management purposes.
- *Time horizon*: VaR models are based on a relatively short time horizon, whereas credit exposure must be defined over many time horizons. The trend (i.e., drift) of market variables, their underlying volatility, and their levels of co-dependence become relevant for credit exposure, whereas for VaR, these elements are irrelevant due to the short time horizon. Also, while VaR tends to ignore future contractual payments and changes such as exercise decisions, cash flows, and cancellations, credit exposure must take these elements into account because they tend to create path dependency (i.e., credit exposure in the future depends on an event occurring in the past).
- *Risk mitigants*: Netting and collateral are examples of risk mitigants, designed to reduce the level of credit exposure. In order to estimate future levels of credit exposure, these mitigants need to be taken into account. Netting requires that the proper rules be applied, which may add a level of complexity. Future collateral adds a significant element of subjectivity, as the type of collateral and time to receive collateral must all be modeled even though they may be unknown.

Credit Exposure Factors

LO 36.c: Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure.

The credit exposure profile is impacted by several factors, including:

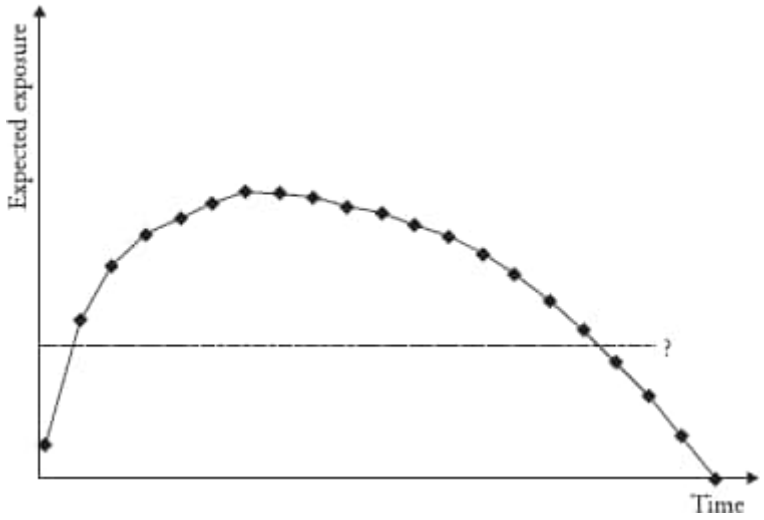
- *Future uncertainty*: In situations where there is a single payout at the end of the life of a contract, uncertainty regarding the value of the final exchange increases over time. Foreign exchange forwards and FRAs often have single payouts at the end of their contract lives.
- *Periodic cash flows*: Unlike the situation where there is a single payout, when cash flows occur regularly, the negative impact of the future uncertainty factor is reduced. However, additional risk exists when periodic cash flows are not equal in each period and are based on variables that may change as is often the case in an interest rate swap with variable interest rates.
- *Combination of profiles*: This exists when the credit exposure of a product results from the combination of multiple underlying risk factors. A cross-currency swap (which combines a foreign exchange forward trade with an interest rate swap) is a good example of this factor.
- *Optionality*: Exercise decisions (e.g., a swap-settled interest rate swaption) will have an impact on credit exposure.

Collateral will also have a significant impact on credit exposure, as it typically reduces the level of credit exposure. However, determining the true level of risk reduction must take into account key parameters (e.g., minimum transfer amounts, thresholds, etc.); the margin period of risk; and other risks associated with collateral such as liquidity, operational risk, and legal risk.

In addition, the reality is that risk is not removed entirely even with collateral due to factors such as delays in receiving collateral, variations in collateral value (i.e., when the collateral is something other than cash), the granularity effect (i.e., key parameters prevent asking for all of the collateral actually required), and the path dependency of collateral (i.e., the amount called for depends on the amount collected in the past).

MODULE QUIZ 36.1

1. Which metric for credit exposure is represented by the "?" in the following graph?



A. Expected positive exposure (EPE).
B. Potential future exposure (PFE).
C. Effective expected exposure (EE).
D. Effective expected positive exposure (EPE).

MODULE 36.2: SECURITY EXPOSURE PROFILES

LO 36.d: Identify typical credit exposure profiles for various derivative contracts and combination profiles.

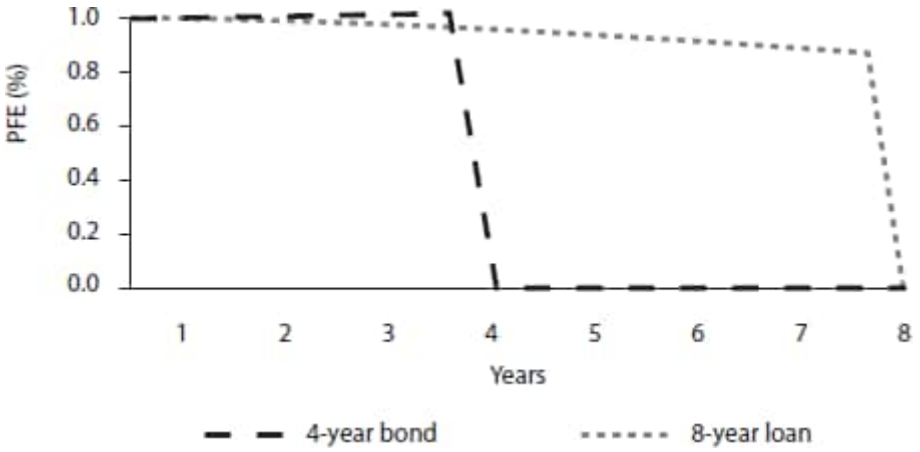
Potential future exposure (PFE) is defined as the maximum expected credit risk exposure for a specified period of time at a prespecified level of confidence. PFE is a measure of counterparty and credit risk exposures. Thus, the maximum credit risk exposure indicated by a PFE analysis is the upper bound on a confidence interval for future credit risk exposure. The ability to quantify counterparty credit exposure is impacted by time to maturity. There is more uncertainty related to market variables further into the future.

Examples of PFE are used to illustrate the credit exposure profile of various security types that result from different sources (e.g., maturity, option exercise, payment

frequencies, default risk, and roll-off risk). In this section, a 99% confidence level is used to create the PFEs.

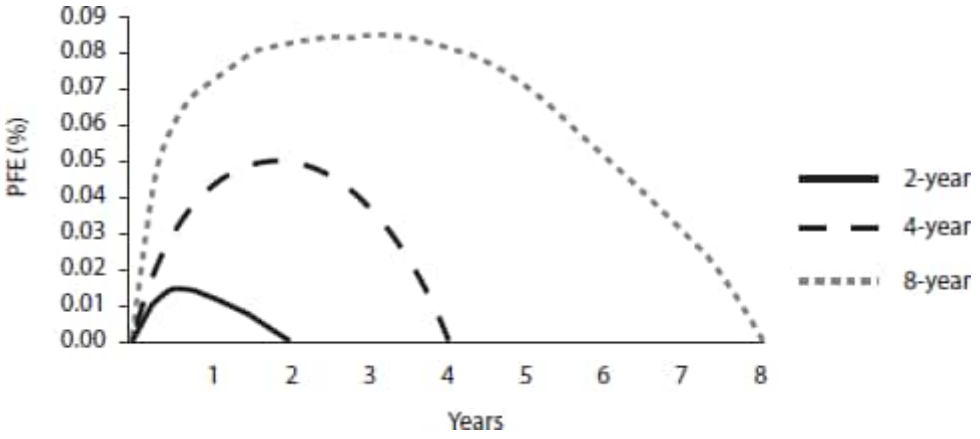
The PFE of bonds, loans, and repos are approximately equal to the notional value. The additional exposure of a four-year bond, as shown in Figure 36.5, is the result of interest rate risk. Bonds typically pay a fixed interest rate. If interest rates decline, then the exposure may increase. Figure 36.5 also illustrates the exposure for an eight-year loan. Loans typically have variable interest rates, and the exposure over time may decrease as a result of prepayments.

Figure 36.5: Loan and Bond PFE



Exposure profiles of swaps are typically characterized by a peak shape, as illustrated in Figure 36.6. This peaked shape results from the balancing of future uncertainties over payments and the roll-off risk of swap payments over time.

Figure 36.6: Interest Rate Swap PFE



The high volatility of FX rates, long maturities, and large final payments of notional value result in monotonically increasing exposures for foreign exchange products. Figure 36.7 illustrates that there is some exposure associated with interest rate risk (IR); however, the majority of the exposure results from the uncertainty regarding the final notional value payment associated with FX rate risk.

Figure 36.7: Three-Year Cross-Currency Swap PFE (Exposure Impact of Interest

and FX Rates)

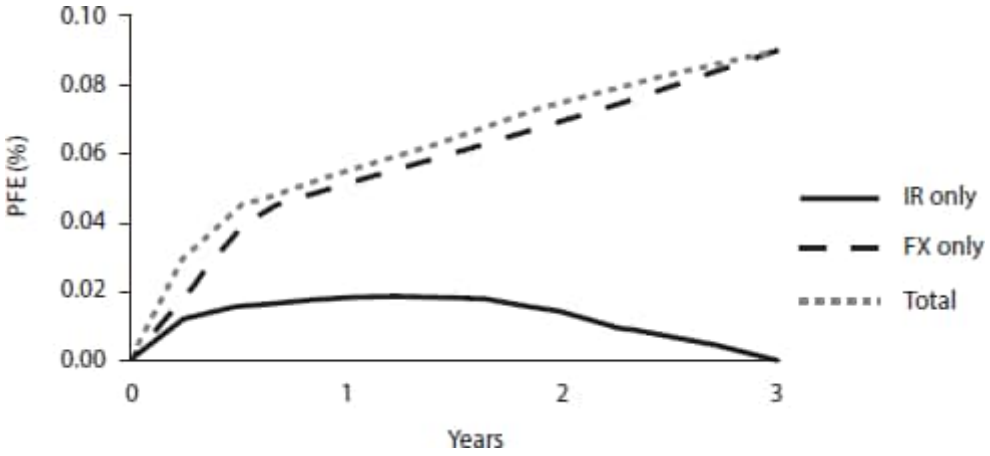
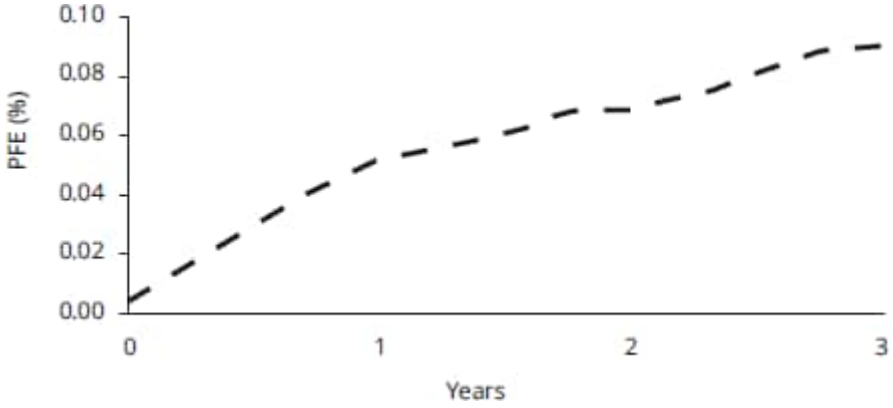


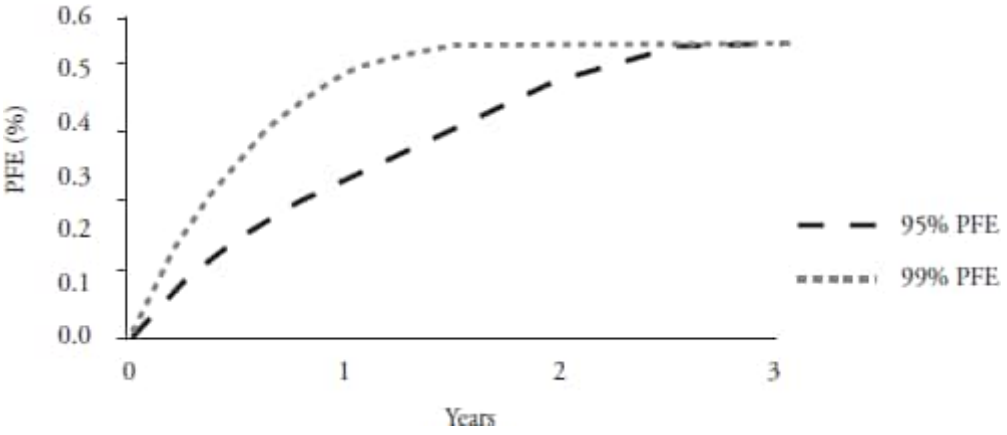
Figure 36.8 provides an exposure profile for a long option position (with up-front premium) and illustrates the increase over time of the exposure until the option is exercised. The exact shape of the graph can change when the option is near, in, or out of the money. However, the increase over time is similar for all options due to the fact that the option can be deep in the money.

Figure 36.8: Option PFE



The effect of **wrong-way risk** leads to considerable counterparty risk for credit derivatives. Figure 36.9 illustrates the exposures for a long-protection credit default swap (CDS) at the 95% and 99% confidence levels. The increase in exposures in early years is the result of the CDS premium (or credit spread) widening. The maximum exposure for the CDS occurs at a credit event where the notional value is paid less the recovery value. The 55% final exposure in this example is the result of a 45% recovery rate.

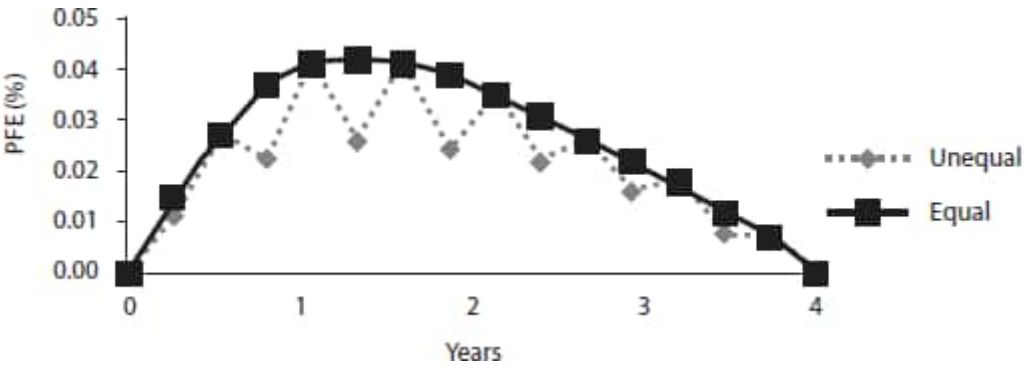
Figure 36.9: Credit Derivative PFE



LO 36.e: Explain how payment frequencies and exercise dates affect the exposure profile of various securities.

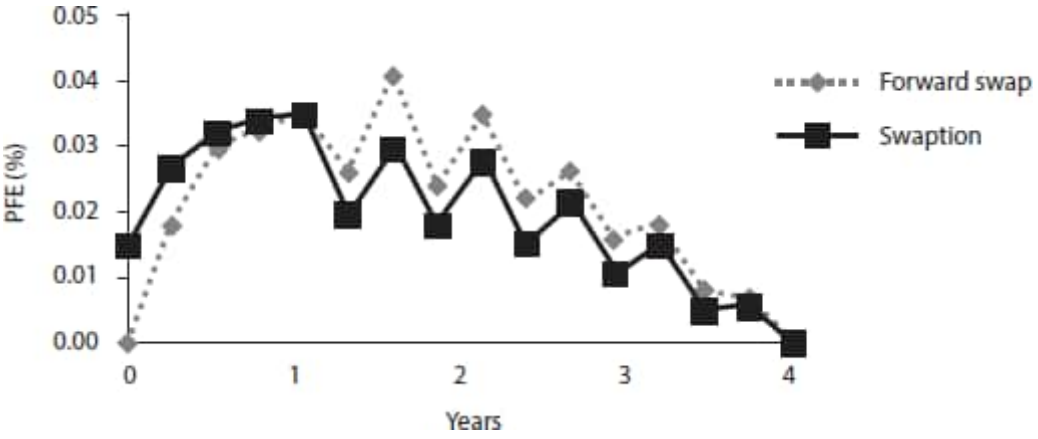
To illustrate the impact of payment frequencies, we can compare interest rate swap PFEs, assuming semiannual fixed payments are made and floating quarterly payments are received. Figure 36.10 illustrates that with unequal payments there is reduced exposure when payments are received more frequently than payments are made. Conversely, if a PFE were created for an interest rate swap where interest payments made were more frequent than interest payments received, it would have the reverse effect. In that case, the unequal payment PFE would show greater exposure than the equal payment PFE.

Figure 36.10: PFE for Swap With Equal and Unequal Interest Payments



Exercise dates result in more complex exposure profiles as illustrated in Figure 36.11, which shows an exposure profile for an interest rate swaption and forward swap with an exercise date of one year. The swaption in this example is swap-settled (as opposed to cash-settled) on the expiration date. The payment frequencies also differ for the swaps in this example. When compared to a forward swap, notice that the exposure is greater for the swaption prior to the one-year exercise date. This relationship reverses after the exercise point and the exposure for the forward swap is greater than the exposure for the swaption. This greater exposure is due to the fact that in some scenarios the forward swap has a positive value and the swaption is not exercised.

Figure 36.11: PFE for Interest Rate Swaption and Forward Swap



Modeling Netting Agreements

LO 36.f: Explain the general impact of aggregation on exposure, and the impact of aggregation on exposure when there is correlation between transaction values.

Netting agreements allow two parties to net a set of positions should one of the parties default. This type of risk is effectively modeled in Monte Carlo simulations. The benefits of netting are realized when MtM values have opposite signs for two trades. Thus, the netting calculation is done at the individual level prior to calculating the total expected exposure (EE). A single time horizon netting factor is defined by EE, and a weighted average EE over time defines the expected positive exposure (EPE).

It is also important to consider the relationship between netting and correlation. Positive correlations have lower netting benefits than negative correlations, with perfect positive correlation providing the least netting benefit. High positive correlations likely result in trades that are of the same sign, resulting in a small or zero netting benefit.

Figure 36.12: Netting With Positive Correlations

	MtM		Total Exposure		
	Trade 1	Trade 2	No Netting	Netting	Netting Benefit
Scenario 1	15	5	20	20	0
Scenario 2	5	−5	5	0	5
Scenario 3	−5	−15	0	0	0
EE			8.3	6.7	1.7

PROFESSOR'S NOTE
EE, or expected exposure, is the average of the netting figures assuming equal weight.

We can, therefore, easily see that negative correlations provide stronger netting benefits, with perfect negative correlation leading to the greatest netting benefit. In this

case, trades are perfectly offsetting, and the netting benefit is 100% because there is zero overall risk.

Figure 36.13: Netting With Negative Correlations

	MtM		Total Exposure		
	Trade 1	Trade 2	No Netting	Netting	Netting Benefit
Scenario 1	15	−5	15	10	5
Scenario 2	5	5	10	10	0
Scenario 3	−5	15	15	10	5
EE			13.3	10.0	3.3

Overall, we can derive the following netting formula for the **netting factor** for any set of jointly distributed random variables across different asset classes:

$$\text{netting factor} = \frac{\sqrt{n + n(n-1)\bar{\rho}}}{n}$$

where:

n = number of exposures

$\bar{\rho}$ = average correlation

The netting factor will, therefore, be 100% when there is no netting benefit (correlation is 1) and 0% if the netting benefit is maximized. We also see that the netting benefit improves (i.e., netting factor declines) with a larger number of exposures and a lower correlation. If correlation is zero, the formula simplifies to $1 / \sqrt{n}$, implying that the netting factor for two independent exposures will be reduced to 71%, and for four exposures the netting factor declines to 50%.

PROFESSOR'S NOTE

There is a restriction on the correlation level in the netting factor equation. The maximum negative correlation must be bounded by [−1 / (n − 1)] in order to prevent the expression under the square root from becoming negative.

Finally, it is important to note that the netting benefit also depends on the initial MtM of transactions. For example, a trade with strong overall negative MtM under all scenarios will have a strong netting benefit by offsetting some or all of the positive MtM of other trades. Similarly, a trade with strong overall positive exposure under all scenarios will reduce the netting benefit by offsetting some or all of the negative MtM of other trades.

MODULE QUIZ 36.2

1. Miven Corp. has two trades outstanding with one of its counterparties. Which of the following scenarios would result in the greatest netting advantage for Miven?
   A. The two trades have strong positive correlation.
   B. The two trades have weak positive correlation.
   C. The two trades are uncorrelated with each other.
   D. The two trades have strong negative correlation.

2. Which of the following security types will most likely result in a peaked shape for the exposure profile represented by potential future exposure (PFE)?

A. Long option position.
B. Foreign exchange product.
C. 10-year loan with a floating rate payment.
D. Swap.

3. Which of the following statements best describes the benefit of netting risk exposures? The benefits of netting are realized when:
A. marked-to-market (MtM) values have high structural correlations for two trades.
B. marked-to-market (MtM) values have opposite signs for two trades.
C. expected exposure (EE) values are minimal.
D. expected future exposure (EFE) values have zero correlation.

MODULE 36.3: COLLATERAL AND CREDIT EXPOSURE

LO 36.h: Explain the impact of collateralization on exposure and assess the risk associated with the remargining period, threshold, and minimum transfer amount.

When Party A has a positive exposure (e.g., receives cash flows in a swap transaction from Party B), Party A is said to have credit exposure because Party B could default. When exposure (i.e., mark-to-market value) is negative, Party A must post collateral to Party B to minimize the credit risk exposure.

When calculating an exposure profile, a risk manager should understand the factors that affect the collateral's ability to reduce risk. Specifically, factors that affect the calculation of exposure include thresholds, minimum transfer amounts, rounding, initial margin, and the margin period of risk. These factors will be discussed later in this section.

The **margin period of risk (MPoR)**, also known as the remargin period, is the period from which a collateral call takes place to when collateral is actually delivered. It is a period of extreme exposure to the counterparty seeking collateral. A prudent risk analyst will assume default of the counterparty that must post collateral during the MPoR. Steps that enter into the calculation of the number of days in the MPoR are as follows:

Step 1: Valuation/margin call: How long it takes to calculate current exposure to the counterparty and the market value of the collateral. These calculations help to determine if a valid call may be made.

Step 2: Receiving collateral: The period between when the counterparty receives the request and when it releases the collateral.

Step 3: Settlement: The time it takes to sell the collateral for cash. The type of security being settled determines the time necessary. Cash may be posted on an intraday basis, whereas government and corporate bonds may need one- and three-day settlement periods, respectively.

Step 4: Grace period: The amount of time afforded to the counterparty obligated to deliver the collateral in the event that the collateral is not received by the requesting counterparty after the call. This may be a short window of time before the delivering counterparty would be considered in default for a failure-to-pay credit event.

Step 5: Liquidation/close-out and re-hedge: The time needed to liquidate the collateral, close out, and re-hedge positions.

An example of a MPoR time line is found in Figure 36.14, along with the minimum period lengths that must be assumed according to Basel II. Over-the-counter (OTC) derivatives and repurchase agreements (repos) are separated as they are governed by different documentation. The length of a MPoR is a function of the collateral agreement, the counterparty in question, legal considerations, and the management structure of the institution in question. Also, the counterparty requesting the collateral could show leniency toward certain counterparties in the interest of maintaining harmonious business relationships.

Figure 36.14: MPoR Time Line

	OTC Derivatives	Repos
Valuation/margin call	2 days	_
Receiving collateral	1 day	1 day
Settlement	2 days	1 day
Grace period	3 days	_
Liquidation/close-out and re-hedge	2 days	1 day
Total	10 days	3 days
Basel II minimum period	10 days	5 days

Measuring Exposure During the MPoR

Both expected exposure and potential future exposure measure the volatility of exposure over a given period of time. **Expected exposure (EE)** is the expected value of an exposure at a given point in time. During the MPoR, it is calculated as:

$$EE = \frac{1}{\sqrt{2\pi}} \times \sigma_E \times \sqrt{T_M} \approx 0.4 \times \sigma_E \times \sqrt{T_M}$$

where:

σ_E = volatility of collateralized exposure

$\sqrt{T_M}$ = MPoR frequency (in years)

Potential future exposure (PFE) is what the value of the marked-to-market exposure might be at some future point in time. During the MPoR, it is calculated as:

$$PFE = k \times \sigma_E \times \sqrt{T_M}$$

where:

k = constant that is a function of the confidence level
(e.g., k = 2.33 for a 99% confidence level)

EXAMPLE: Computing PFE

Calculate the worst-case change in the value of an exposure with 7% annual volatility perfectly collateralized by cash over a 10-day MPoR. Assume 250 trading days in the year and a 99% PFE confidence level.

Answer:

$$\text{PFE} = -2.33 \times 7\% \times \sqrt{10/250} = -3.3\%$$

Potential disadvantages of PFE calculations include:

- It assumes a strongly collateralized position. PFE fails to work under a large threshold or minimum transfer amount, which produces a partially uncollateralized exposure.
- The analysis fails to account for the uncertainty of collateral volatility.
- Liquidity and liquidation risks are not considered.
- Volatility may differ from expected or implied volatility at the time of the collateral call and may not assume counterparty default.
- Wrong-way risk is not taken into account.

Collateral volatility must be calculated when a decline in the value of noncash collateral has the potential to create undercollateralization. The PFE formula is used for this calculation.

When there is no correlation between the volatility of the underlying exposure and that of the collateral, overall volatility is calculated as follows:

$$\sqrt{\text{variance of noncash collateral} + \text{variance of underlying exposure}}$$

For example, if the volatility of the noncash collateral was 8% and the volatility of the underlying exposure was 5%, the overall volatility would be computed as:

$$\sqrt{8\%^2 + 5\%^2} = 9.4\%$$

This volatility measure would be used in the PFE formula to reflect the additive exposure of the collateral and volatility of the underlying exposure. In this example, collateral lessens exposure but increases the volatility of the position due to the volatility inherent in the collateral itself.

There are also situations where there is a negative or positive correlation, ρ, between the trade and the collateral. For example, assume a 10-year swap is collateralized with a 15-year government bond that is interest rate–sensitive. The volatilities are 4% for the swap and 6% for the bond. The effective volatility of this position is calculated as follows:

$$\text{effective volatility} = \sqrt{4\%^2 + 6\%^2 - 2 \times 4\% \times 6\% \times \rho}$$

The overall risk of the position as a function of correlation is then calculated as:

$$k \times \text{effective volatility} \times \sqrt{T_M}$$

Modeling Collateral

Quantifying how much collateral reduces credit exposure is important. The risks that arise during the process of collateralizing exposure are discussed in the following.

Collateralization may be deficient due to terms in the collateral agreement, such as threshold, minimum transfer amount, and rounding. These factors may result in less than full collateralization. The following expression represents imperfect collateralization:

$$\text{exposure}_{t-\Delta} > \text{collateral}_{t-\Delta}$$

where:
t = time
Δ = time since collateral was last received (MPoR)

Exposure could increase between margin calls. The increased amount of exposure may not be collateralized. The following expression represents the portion of exposure not collateralized:

$$\text{exposure}_{t} > \text{exposure}_{t-\Delta}$$

Collateral is path-dependent. This means that the amount of collateral requested depends on how much was requested in the past.

Certain parameters impact the effectiveness of collateral in lessening credit exposure. These parameters are as follows:

1. **Margin period of risk**: the time between the call for collateral and its receipt.
2. **Threshold**: an exposure level below which collateral is not called. It represents an amount of uncollateralized exposure.
3. **Minimum transfer amount**: the minimum quantity or block in which collateral may be transferred. Quantities below this amount represent uncollateralized exposure as well.
4. **Initial margin**: an amount posted independently of any subsequent collateralization. This is also referred to as the initial margin.
5. **Rounding**: the process by which a collateral call amount will be adjusted (rounded) to a certain increment.

Differences Between Funding and Credit Exposure

LO 36.g: Describe the differences between funding exposure and credit exposure.

Funding costs and benefits are associated with positive and negative credit exposures, respectively. If a counterparty defaults, it creates the potential for positive credit exposure, which results in a funding cost to the firm. If the firm itself defaults, it creates the potential for negative credit exposure, which results in a funding benefit. Posting margin against a positive exposure will decrease both funding costs and counterparty risk, while posting margin against negative exposure will decrease both funding benefits and exposure from the counterparty's point of view.

Despite these connections, there are some differences between funding and credit exposure that should be recognized. Differences include:

- *Defining value*: How value is defined for credit exposure is subjective and depends on assumptions related to close-out procedures. For funding exposure, value is objective since it is also present in non-defaulting situations.
- *Margin period of risk*: This measure considers counterparty default and is used when computing credit exposure. For funding exposure, the associated funding delay does not necessarily assume counterparty default. Thus, the funding value adjustment could be zero even if the associated credit value adjustment is non-zero.
- *Aggregation*: Credit exposure arises in default; therefore, it is concerned with netting values. With funding exposure, the entire portfolio may be considered since margin from different counterparties can be reused.
- *Wrong-way risk*: This concept is associated with the measurement of credit exposure and not a key consideration for funding.
- *Segregation*: This concept restricts the use of margin, so it impacts credit and funding exposure differently.

Impact of Collateral on Counterparty Risk and Funding

LO 36.i: Assess the impact of collateral on counterparty risk and funding, with and without segregation or rehypothecation.

Counterparty risk and funding costs can be reduced by posting certain types of collateral. Counterparty risk can be mitigated by taking ownership of collateral in the event of counterparty default, and funding costs can be mitigated by posting collateral against other transactions. In order to maximize both counterparty risk mitigation and funding benefits, the collateral posted must not exhibit wrong-way risk and it must be reusable (i.e., not segregated). The impact of different types of collateral on counterparty risk and funding costs can be examined under the following scenarios:

- *Cash that is not segregated*. This mitigates both counterparty risk and funding costs.
- *Securities that can be rehypothecated*. This mitigates both counterparty risk and funding costs, given that the haircuts are sufficient.
- *Cash and securities that must be segregated and cannot be rehypothecated*. This mitigates counterparty risk but does not provide funding benefits because the collateral cannot be reused under a non-default scenario.
- *Counterparty bonds that can be rehypothecated*. This mitigates funding costs but is problematic for counterparty risk mitigation because bonds will be in default when required.

MODULE QUIZ 36.3

1. Time steps that enter into the calculation of the number of days in the margin period of risk include all of the following except:
   A. valuation/margin call.
   B. posting collateral.
   C. settlement.

D. close-out and re-hedge.

KEY CONCEPTS

LO 36.a

Important metrics for credit exposure include the following: expected MtM, expected exposure (EE), potential future exposure (PFE), expected positive exposure (EPE), expected negative exposure (ENE), effective EE, effective EPE, and maximum PFE.

LO 36.b

Although value at risk (VaR) and credit exposure are similarly used to estimate the risk of loss, additional considerations related to credit exposure that must be accounted for include how it is applied (exposure is defined for pricing and risk management), the time horizon (exposure has a much longer time horizon than VaR), and risk mitigants (netting and collateral).

LO 36.c

The credit exposure profile is impacted by factors such as future uncertainty, periodic cash flows, profile combinations, and optionality. Collateral will also impact exposure, typically in a favorable way. However, risk reduction may be limited by the existence of key parameters (thresholds, minimum transfer amounts), characteristics of collateral (delays, value variations, granularity, path dependency), and other risks (liquidity, operational, legal) associated with collateral.

LO 36.d

The PFE of bonds, loans, and repos are approximately equal to the notional value or 100%. PFEs of swaps have a peaked shape. PFEs of long option positions or FX products monotonically increase. The maximum PFE for credit default swaps occurs at a credit event where the notional value less the recovery value is paid.

LO 36.e

With unequal payments, there is reduced exposure that results when payments are received more frequently than payments are made. Exercise dates result in more complex exposure profiles.

LO 36.f

Positive correlations between contract mark-to-market values have lower netting benefits than negative correlations, with perfect positive correlation providing the least netting benefit and perfect negative correlation the most benefit.

LO 36.g

Funding costs and benefits are associated with positive and negative credit exposures, respectively. Despite some connections, differences between funding and credit exposure are present in defining value, the margin period of risk, aggregation of exposures, wrong-way risk, and segregation.

LO 36.h

The margin period of risk (MPoR) is the period from which a collateral call takes place to when collateral is actually delivered.

Factors that affect the calculation of the exposure profile when taking collateral into account include:

- MPoR: creates exposure.
- Minimum transfer amount (≠ threshold amount): creates exposure below the minimum transfer amount.
- Threshold (≠ minimum transfer amount): creates exposure below the threshold.
- Initial margin: may reduce exposure, depending on its size.
- Rounding: may create a small amount of exposure, depending on the direction of the rounding.

Assumptions and parameters in modeling collateral include (1) terms of the collateral agreement, (2) risk of increased exposure between margin calls, and (3) path dependency of collateral.

LO 36.i

Counterparty risk and funding costs can be reduced by posting certain types of collateral. The impact of the type of collateral can be examined with and without segregation or rehypothecation.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 36.1

1. **A** EPE is equal to average EE over time. It is a useful single amount to quantify exposure. (LO 36.a)

Module Quiz 36.2

1. **D** The greatest netting benefit among the scenarios presented occurs when the two trades have a strong negative correlation. In this case, a large portion of the negative exposures will offset positive exposures. (LO 36.f)
2. **D** Exposure profiles of swaps are typically characterized by the peaked shape that results from balancing future uncertainties over payments and roll-off risk of swap payments over time. (LO 36.e)
3. **B** The benefits of netting are realized when MtM values have opposite signs for two trades. (LO 36.f)

Module Quiz 36.3

1. **B** The time period from which the request for collateral is received to which it is released refers to the receipt of collateral, but it does not involve its actual posting. All of the remaining items are part of the MPoR. (LO 36.h)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. Cross-reference to GARP assigned reading—Gregory, Chapter 17.

READING 37

CVA

Study Session 6

EXAM FOCUS

The pricing of counterparty risk is a function of the credit exposure and default probability of a counterparty. For the exam, know how to calculate a credit value adjustment (CVA) in the presence of unilateral contracts. Also, understand the concepts of incremental and marginal CVA, and know how to estimate CVA as a spread. Finally, be able to explain both wrong-way risk and right-way risk as well as identify these risks in transactions such as put options, call options, credit default swaps, foreign currency transactions, interest rate and currency swaps, and commodities.

MODULE 37.1: CREDIT VALUE ADJUSTMENT

LO 37.a: Explain the motivation for and the challenges of pricing counterparty risk.

The pricing of counterparty risk (i.e., how much to charge a counterparty for the risk that it may default) is a function of the credit exposure and default probability of a counterparty. Accurate pricing of a counterparty's risk generates reserves to absorb potential losses due to that counterparty's default. Pricing counterparty risk needs to account for risk mitigants (e.g., netting, collateralization).

The price of counterparty risk approximates to the value of the risk of all outstanding positions with a counterparty and exists in addition to the price of the financial instrument itself that the counterparties use (e.g., a swap). Best practices will organize responsibilities as to who should calculate counterparty risk within the financial institution. The challenge in pricing this type of risk arises with bilateral derivatives contracts (e.g., swaps with fixed and floating components) rather than one-way payment instruments such as bonds.